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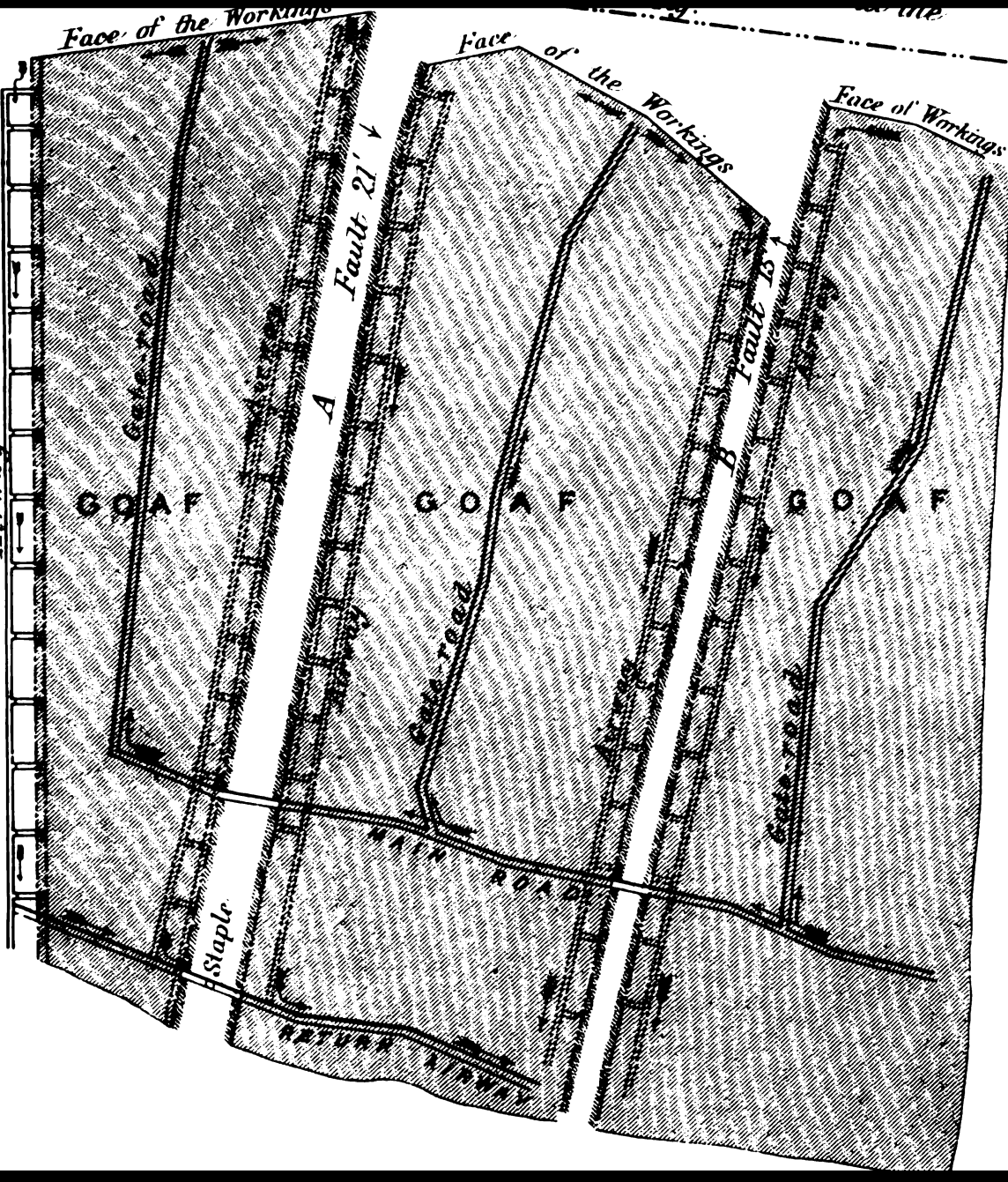

Transactions

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of Mining and Mechanical Engineers

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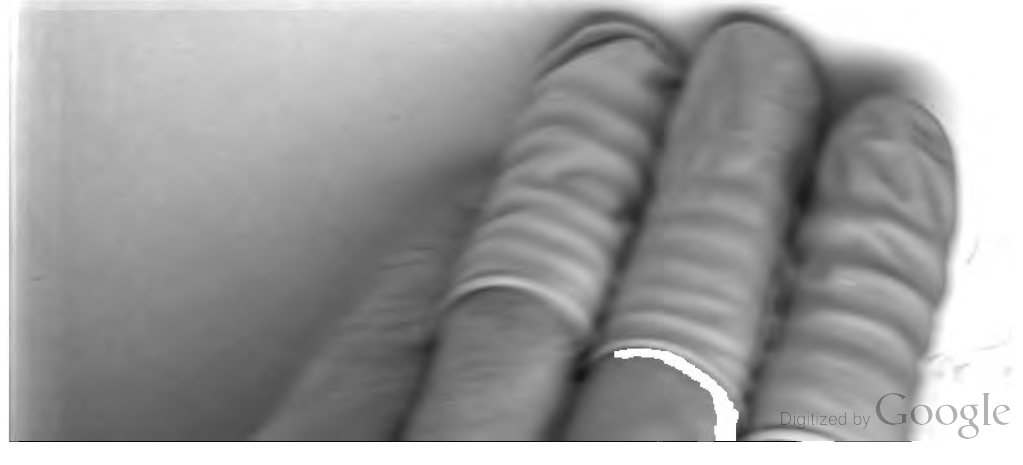
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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. XXXII.

1882-83.

NEWCASTLE-UPON-TYNE: A. REID PRINTING COURT BUILDINGS, AKENSIDE HILL.

1883.

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11, 2923, July 11

NEWCASTLE-UPON-TYNE:

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

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Report.

THE Council have much pleasure in being able to report that for the first time for five years there has been a substantial increase in the number of members, and that in the thirty-first year of its existence the Institute is in a well established and prosperous condition. One of the subjects that the Council congratulate the members upon, is the constant variable additions which are being made to the Library. The shelves are now full of books which are of great service to the members, and it will shortly be the duty of the Council to provide book-shelves for the constant increase in the works which are being received from Foreign Exchanges and by purchase.

The year which has passed has been exceptionally interesting to the members, inasmuch as they had opportunity of making two very entertaining excursions; one at the invitation of Sir Edward Watkin to visit the Channel Tunnel works at Dover, when, through the kindness of that gentleman, they were supplied with free railway passes from their several habitations to Dover and back. The trip was a most enjoyable one, upwards of 120 gentlemen availing themselves of this opportunity to see the Tunnel, and the amount of information gained by an inspection of the works was very great. The "Boring Machine," by Colonels Beaumont and English, and the "Air Locomotive," by Colonel Beaumont, which were set at work by the permission of the Board of Trade for the occasion, enabled the members to form a pretty correct idea of the facilities which could be afforded by these powerful machines in the construction of the Tunnel when the time arrives for practically pursuing this interesting work.

The second visit the Institute made was to Barrow-in-Furness, through the invitation of Mr. J. T. Smith and the Directors of the "Barrow Hæmatite Steel Company, Limited." About 130 members availed themselves of the invitation, and were received with great hospitality, and the whole of the mining and manufacturing industries of the district were thrown open to their inspection.

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The papers read before the Institute have been above the usual calibre. One on the "Channel Tunnel," by Mr. Charles Tylden-Wright, contains much valuable geological information, in addition to a very interesting description of the machinery which has been specially invented to make the borings.

Mr. Charles Parkin contributed a very valuable paper on the "Mineral Resources of the Rosedale Abbey District," and Mr. J. H. Grant one on the "Daltonganj Coal-field of India." The most interesting geological paper that has been received is one from Mr. J. D. Kendall, on the "Structure of the Cumberland Coal-field," the illustrations being exceedingly well delineated. Mr. Charles Hunting, who has devoted a considerable amount of his time to the study of the most economical mode of feeding and managing horses, and had great experience in carrying out the results of his research in the collieries of the North of England, contributed a most interesting and exhaustive paper on "The Feeding and Management of Colliery Horses." This paper, together with the discussion which took place upon it, forms a most valuable addition to the Transactions. Mr. Gresley contributed a paper on "Two Systems of Working the Main Coal at Moira, Leicestershire."

Papers also have been read on the more mechanical departments of colliery management; by Mr. W. J. Bird, on "Non-conducting Coverings for Boilers and Steam-pipes," and by Mr. Bowlker, on a "New Ventilating Fan;" and this division has further been very interestingly augmented by the valuable paper of Mr. Marten, on the "Explosions of Boilers and other Vessels."

A purely mathematical paper by Professor Aldis, on "The Internal Stress of Cylindrical and Spherical Dams," has also been printed, which will afford, no doubt, reliable data to enable the members to construct these important erections.

One of the most interesting papers read before the Institute this year, is the one read by Mr. Vincent W. Corbett, "On Water-gauge, Barometer, and other Observations taken at Seaham Colliery during the time the Maudlin Seam was sealed up," It is illustrated by no less than seventy-one diagrams of great complexity, taken from the original drawings.

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Finance Report.

It will be seen from last year's Report that the income of the Institute at the close of the year 1881-82 amounted to £2,176 9s. 10d., and it was stated that this had been, financially, the most successful year of the Institute; it was shown, however, that a part of this increase was accounted for by the third half-yearly dividend of £107 4s. 0d. having been paid to the Institute, through the Directors of the "Institute and Coal Trade Chambers Company, Limited," paying their dividends half-yearly instead of yearly.

The income of the past year has been £1,970 1s. 1d., or £206 8s. 9d. less than the preceding year; this is partly accounted for, as explained above, by the extra half-yearly dividend obtained last year, by a decrease of £40 17s. 0d. in the amount of the subscriptions obtained this year, and a decrease of £84 12s. 5d. in the sale of the Transactions. There has been an increase of 14 in the number of members, and the amount of arrears is slightly less, being £431 11s. 0d., as against £493 10s. 0d. of last year. It is to be regretted that the amount of arrears continues to form so large a feature in the Balance Sheet, and notwithstanding the efforts that are made to gather in the subscriptions, it seems impossible ever materially to diminish the amount.

The income, however, has exceeded the expenditure by £157 9s. 11d., and the Committee have to report that the year, financially speaking, has been a fairly average one, and that the finances of the Institute are in a highly satisfactory state.

WM. COCHRANE.
JOHN DAGLISH.

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AWARDS FOR PAPERS WHICH HAVE APPEARED IN THE TRANSACTIONS OF THE INSTITUTE.

THE Council having, in October, 1872, decided to recommend that prizes of books not exceeding £50 in value should be awarded and apportioned to the writers of such papers printed in the Transactions as the Council should decide, and this recommendation having been approved by a General Meeting of the members, and awards made at various times by a Committee appointed for the purpose, the Secretary was requested by the Council to report on the proceedings and present position of the Committee, and to furnish an account of all sums which had been awarded by them, and he presented the following Report, which was ordered to be printed, and it was decided that the particulars of subsequent awards should be published each year :—

TO THE COUNCIL OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENTLEMEN,—As desired by the Council, I produce a list of all the prizes awarded by the several Committees appointed for that purpose from the commencement of the grant.

The last Committee was nominated on the 25th March, 1882, and was charged with the distribution of prizes for papers which appeared in Vols. XXIX. and XXX., and it does not seem to be within its province to extend its labours. At present there is only one volume which has not been adjudicated upon, and that is Vol. XXXI., as XXXII. is not yet completed.

THEO. WOOD BUNNING.

September 19th, 1883.

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VOLUME XXII.

Name.	Title of Paper.	Amount. £	s.	d.
A. L. Steavenson... ...	On the Experience afforded in the Manufacture of Coke during the last Twelve Years	8	0	0
E. Bainbridge	On Coppee's Patent Coke Ovens, and the extent to which their Waste Gases can be Utilized	5	0	0
G. A. Lebour	On the Geology of the Redesdale Ironstone District	3	0	0
E. Gilpin	On the Pictou Coal-field	3	0	0
C. Wawn	A General Description of the different Systems of Opening Bridges	3	0	0
T. W. Bunning	Barometer and Thermometer Readings, 1872	3	0	0
		25	0	0

VOLUME XXIII.

D. P. Morison	On Fowler's Patent Apparatus for Loading and Unloading Pit Cages	5	0	0
John Wallace	On the Combustion of Coal Gas to produce Heat	5	0	0
J. B. Simpson	Translation of Messrs. Cornet and Briart's Notice of Natural Pits in the Coal-measures of Belgium	3	0	0
T. W. Bunning	Translation of a Paper on Raising Coals from great Depths by Atmospheric Pressure, on the System of Mons. Blanchet	3	0	0
J. F. Hedley	On the Valuation of Mines for the purpose of Local Taxation	5	0	0
E. Gilpin	On the Coal-measures and Lower Carboniferous Strata of Western Newfoundland	5	0	0
T. F. Brown	On the South Wales Coal-field	15	0	0
T. W. Bunning	Barometer and Thermometer Readings, 1873	3	0	0
		44	0	0

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VOLUME XXIV.

Name.	Title of Paper.	Amount. £	s.	d.
J. B. Simpson	On the Coal-fields and Mining Industries of Russia	5	0	0
J. Daglish and R. Howse.	On the Beds of Ironstone occurring in Lincolnshire	5	0	0
R. S. Newall	On Supplying Newcastle and District with Water from Lake Ullswater	5	0	0
W. Galloway	On Safety-lamps and Shot Firing	5	0	0
G. A. Lebour	On the Little Limestone and its accompanying Coal in South Northumberland	5	0	0
T. J. Bewick	On a Project for Supplying Newcastle-on-Tyne, Gateshead, and other Towns and Villages in Tynedale with Water from the Northumberland Lake District	5	0	0
T. W. Bunning	On the Present Form of Marine Engine used in the Commercial Navy of Great Britain...	5	0	0
E. Gilpin	On the Submarine Coal of Cape Breton, N.S.	5	0	0
W. Routledge	On the Sydney Coal-field in the Island of Cape Breton	5	0	0
Dr. H. A. Nicholson ...	On the Mining Districts on the North Shore of Lake Superior	5	0	0
T. W. Bunning	Barometer and Thermometer Readings, 1874	3	0	0
		53	0	0

VOLUME XXV.

W. H. Green	On the Silkstone and Barnsley Seams ...	3	0	0
T. W. Embleton	Notes on the Oaks Colliery Explosion ...	5	0	0
G. A. Lebour	On the Geological Relations of the Secondary Iron Ores of France...	3	0	0
J. J. Williams	On the Mineral Resources of Flintshire and Derbyshire	2	0	0
T. W. Bunning	On the Spontaneous Combustion of Coal ...	3	0	0
E. F. Boyd	Remarks on the Coal-measures and Oil Produce of the United States	10	0	0
J. Daglish...	Application of Counterbalancing and Expansion to Winding Engines	5	0	0
G. A. Lebour	On the Larger Divisions of the Carboniferous System in Northumberland	3	0	0
W. O. Wood	On the Long-wall Workings at East Hetton Colliery	2	0	0
		36	0	0

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Name.	Title of Paper.	Amount. £	s.	d.
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T. W. Bunning	Mon. G. Lambert (translated by T. W. Bunning), A Description of the New Coal Basin Discovered in the Dutch Limburgh (communicated by Mr. C. Archibald); and On the Gowrie Mines, Cow Bay, Cape Breton.	5	0	0
J. Shaw	On a New Form of Marine Boiler	1	0	0
W. Page	A Description of a Winding Engine with Self-acting Variable Expansion	1	0	0
G. A. Lebour and M. Fryar	On the Harkess Rocks, near Bamburgh ...	2	2	0
W. Cockburn	On Cooke's Ventilating Machine	2	0	0
W. Cochrane	On the Advantages of Centrifugal-action Machines for the Ventilation of Mines ...	3	0	0
		16	2	0

VOLUME XXVII.

T. L. Galloway and C. Z. Bunning	A Description of an Instrument for Levelling Underground...	2	0	0
J. B. Simpson	An Account of the Condition of the Mining Industries of Prussia in the Year 1875 ..	2	0	0
D. Burns	On the Intrusion of the Whin Sill	1	0	0
W. Saise	Notes on the Geology of the Bristol Coal-field, with special reference to the Gloucestershire Basin	2	0	0
W. Harle	On Increased Economy in the Manufacture of Coke by Mechanical Means...	1	0	0
C. Parkin	On the Perran Iron Lode in Cornwall and the Mines in the District	1	0	0
H. Laporte	A Geological Sketch of the Northern Coal-field of France	4	0	0
T. L. Galloway	On the Present Condition of Mining in some of the Principal Coal-producing Districts of the Continent	3	0	0
E. Gilpin	On Canadian Coals: their Composition and Uses	4	0	0
E. H. Liveing	On a New Method of Detecting very Small Quantities of Inflammable Gas, and of Estimating the Proportion Present ...	1	0	0
		21	0	0

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VOLUME XXVIII.

Name.	Title of Paper.	Amount. £	s.	d.
A. R. Sawyer	On Mining at Saarbrücken, with an Account of the Structure of the Coal-field	3	0	0
A. F. Marreco and D. P. Morison	An Account of some Recent Experiments with Coal Dust	4	0	0
J. D. Kendall	On the Hæmatite Deposits of West Cumberland	5	0	0
J. Pease	On a New Method of Rope Haulage	1	0	0
		13	0	0

VOLUME XXIX.

James Ashworth	On Improved Safety-lamps of the Davy and Müeseler Types	2	0	0
E. P. Rathbone	Lührig's Method of Coal-washing	3	0	0
W. Logan	On Safety-hooks	3	0	0
		8	0	0

VOLUME XXX.

Dr. Saise	On the Kurhurballee Coal-field, with some Remarks on Indian Coal	3	0	0
E. Gilpin	On the Gypsum of Nova Scotia	2	0	0
D. P. Morison	On Boiler Accidents and their Prevention (Part IV.)	5	0	0
C. Parkin	On the Treatment of Ores	2	0	0
L. Wood	On Experiments showing the Pressure of Gas in the Solid Coal	5	0	0
C. S. Lindsay ...	Report on Mechanical Ventilators ...	5	0	0
E. H. Liveing ...		5	0	0
		27	0	0

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30	@ £2 2s.	63	0	0
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		1,765	4	0
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Deduct—				
To Irrecoverable Arrears not inserted in 1882-83 List (Dead, Resigned, etc.)	235 4 0			
		258	6	0
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Newcastle-upon-Tyne,
3rd August, 1883.

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			PAID. £ s. d.	UNPAID. £ s. d.
By	474	Original Members paid	995 8 0	
By	63	Do. unpaid		132 6 0
By	4	Do. dead, unpaid		8 8 0
By	3	Do. resigned, unpaid		6 6 0
By	5	Do. gone, no address		10 10 0
By	1	Do. struck off		2 2 0
	550			
By	19	Ordinary Members paid	59 17 0	
By	5	Do. unpaid, 1 @ £2 2s., and 4 @ £3 3s.		14 14 0
By	1	Do. resigned, unpaid		3 3 0
	25			
By	68	Associate Members paid	142 16 0	
By	11	Do. unpaid		23 2 0
By	1	Do. dead, unpaid		2 2 0
By	1	Do. gone, no address		2 2 0
	81			
By	1	Student paid as Associate Life Member	20 0 0	
By	88	Students paid	92 8 0	
By	19	Do. unpaid...		19 19 0
By	3	Do. resigned, unpaid		3 3 0
By	3	Do. gone, no address		3 3 0
By	1	Do. struck off		1 1 0
	114			
By	14	Subscribing Collieries paid	71 8 0	
By	1	Do. unpaid		10 10 0
By	1	Do. struck off		2 2 0
	16			
By	7	New Ordinary Members paid	22 1 0	
By	2	New Associate Members paid as Life Members ...	40 0 0	
By	27	Do. paid	56 14 0	
By	3	Do. unpaid		6 6 0
	30			
By	12	New Students paid	12 12 0	
By	1	Do. unpaid		1 1 0
	13			
			1,513 4 0	252 0 0
By Members' Arrears			70 7 0	171 3 0
By Students' Do.			8 8 0	8 8 0
By Arrears considered as Irrecoverable but since paid ...			19 19 0	
			1,611 18 0	431 11 0
				1,611 18 0
				£2,043 9 0

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DR. *For the Year ending*

	£	s.	d.
To Balance at Bankers	537	16	0
To Dividend of 8 per cent. on 134 Shares of £20 each, Institute and Coal Trade Chambers Company, Limited = £2,680	214	8	0
To Rent of College Class Rooms, less Borough Rates	52	7	6
To Literary and Philosophical Society (Wood Memorial Hall)	8	10	0
To Interest on Investment with River Tyne Commissioners	38	18	4
To Wood Memorial Hall	8	0	
	852	7	10
To Subscriptions for 1882-83 from 474 Original Members ... £995 8 0			
To Do. do. 19 Ordinary Members ... 59 17 0			
To Do. do. 68 Associate Members ... 142 16 0			
To Do. do. 88 Students 92 8 0			
To Do. do. 1 do. paid as Member ... 20 0 0			
To Do. do. 7 New Ordinary Members ... 22 1 0			
To Do. do. 27 New Associate Members ... 56 14 0			
To Do. do. 2 New Life Members ... 40 0 0			
To Do. do. 12 New Students 12 12 0			
To Subscribing Collieries:—			
Ashington £2 2 0			
Birtley Iron Co. 6 6 0			
Haswell 4 4 0			
Hetton 10 10 0			
Lambton 10 10 0			
Londonderry 10 10 0			
North Hetton 6 6 0			
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Seghill 2 2 0			
South Hetton 4 4 0			
Stella 2 2 0			
Throckley 2 2 0			
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Wearmouth 4 4 0			
71 8 0			
1,513 4 0			
To Members' Arrears 70 7 0			
To Students' do. 8 8 0			
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	1,611	18	0
To Sale of Publications, per A. Reid 44 12 6			
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40 3 3			
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	43	11	3
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INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

July, 1883. Cr.

	£ s. d.	£ s. d.
By Balance due Treasurer		34 16 5
By Paid A. Reid, Publishing Account	562 16 8	
By Do. Covers for Parts and Stitching	7 1 10	
By Do. Binding and Sewing Volumes	25 12 0	
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		824 4 2
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By Subscription to Natural History Society		20 0 0
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By Awards for Papers		4 17 0
By Abstracts of Foreign Papers		74 7 9
		1,812 11 2
By Balance at Bankers	668 3 9	
By Balance in hands of Treasurer	27 2 2	
		695 5 11

Audited and Certified,
JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
3rd August, 1883.

£2,507 17 1

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DR. GENERAL STATEMENT, AUGUST, 1883. CR.

Liabilities.	£	s.	d.
None	„	„	„
Capital	10,246	7	5
	£10,246	7	5

Audited and Certified
(Share Certificates and Bond produced).
JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
3rd August, 1883.

Assets.	£	s.	d.
Balance of Account at Bankers £668 3 9			
Balance in hands of Treasurer 27 2 2			
	695	5	11
134 Shares of £20 each in the Institute and Coal Trade Chambers Company (Limited)	2,680	0	0
Invested with River Tyne Commissioners	1,000	0	0
Arrears of Subscriptions	431	11	0
Value of 328 Bound Volumes of Transactions, @ 11s. 6d.	188	12	0
Value of 3,991 Sewn Copies of Transactions, @ 9s. ...	1,795	19	0
Value of sundry Sheets and Plates belonging to Vol. XXXII., unfinished at this date	150	0	0
Value of 37 Copies of Mr. T. F. Brown's Map of the South Wales Coal-field, @ 5s....	9	5	0
Value of 394 Copies of General Index, @ 3s.	59	2	0
Value of 757 Copies of Fossil Illustrations, @ 12s. 6d. ...	473	2	6
Value of 864 Copies of Fossil Catalogue, @ 5s.	216	0	0
Value of 841 Copies of Borings and Sinkings, Vol. I., @ 5s.	210	5	0
Value of 349 Copies of Borings and Sinkings, Vol. II., @ 5s.	87	5	0
Value of 1,500 Vols. of Borings and Sinkings in Sheets...	300	0	0
Value of sundry Sheets of Borings and Sinkings belonging to Vol. III., unfinished at this date	50	0	0
Value of Furniture and Office Fittings	300	0	0
Value of Books and Maps in Library	1,600	0	0
	£10,246	7	5

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Patrons.

His Grace the DUKE OF NORTHUMBERLAND.
His Grace the DUKE OF CLEVELAND.
The Most Noble the MARQUESS OF LONDONDERRY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF RAVENSWORTH.
The Right Honourable the LORD WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.
WENTWORTH B. BEAUMONT, Esq., M.P.

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Honorary Members.

	Elected. Orig.	Hon.
The Right Honourable the EARL OF RAVENSWORTH ...		1877
WILLIAM ALEXANDER, Esq., Inspector of Mines, Glasgow ...		1863
JOSEPH DICKINSON, Esq., Inspector of Mines, Manchester ...		1853
THOMAS EVANS, Esq., Inspector of Mines, Pen-y-Bryn, Duffield Road, Derby		1855
* HENRY HALL, Esq., Inspector of Mines, Rainhill, Prescott ...		1876
* RALPH MOORE, Esq., Inspector of Mines, Glasgow		1866
CHARLES MORTON, Esq., The Grange, St. Paul's, Southport ...		1853
* THOMAS E. WALES, Esq., Inspector of Mines, Swansea	1855	1866
* FRANK N. WARDELL, Esq., Inspector of Mines, Wath-on-Dearne, near Rotherham	1864	1868
* JAMES WILLIS, Esq., Inspector of Mines, 14, Portland Terrace, Newcastle-on-Tyne	1857	1871
THOMAS WYNNE, Esq., Inspector of Mines, Manor House, Gnosall, Stafford		1853
WARINGTON W. SMYTH, Esq., 28, Jermyn Street, London ...		1869
The Very Rev. Dr. LAKE, Dean of Durham		1872
* Prof. G. S. BRADY, M.D., F.L.S., College of Physical Science, Newc.		1875
* „ A. S. HERSCHEL, M.A., F.R.A.S. do. do. ...		1872
* „ G. A. LEBOUR, M.A., F.G.S. do. do. ...	1873	1879
* „ P. PHILLIPS BEDSON, D. Sc. (Lond.) do. do. ...		1883
M. DE BOUREUILLE, Commandeur de la Légion d'Honneur, Conseiller d'état, Inspecteur General des Mines, Paris		1853
Dr. H. VON DECHEN, Berghauptmann, Ritter, etc., Bon-am-Rhine, Prussia		1853
M. THEOPHILE GUIBAL, School of Mines, Mons, Belgium ...		1870
M. E. VUILLEMIN, Mines d'Aniche (Nord), France		1878

Life Members.

	Orig.	Life.
C. W. BARTHOLOMEW, Esq., Blakesley Hall, near Towcester ...		1875
THOS. HUGH BELL, Esq., Middlesbro'-on-Tees		1882
DAVID BURNS, Esq., C.E., Clydesdale Bank Buildings, Bank Street, Carlisle		1877
E. B. COXE, Esq., Drifton, Jeddo, P.O., Luzerne Co., Penns., U.S. ...	1873	1874
JAMES S. DIXON, Esq., 170, Hope Street, Glasgow	1878	1880
ERNEST HAGUE, Esq., Castle Dyke, Sheffield	1872	1876
G. C. HEWITT, Esq., Coalpit Heath Colliery, near Bristol	1871	1879
THOS. E. JOBLING, Esq., Bebside Colliery, Cowpen Lane, Northumberland	1876	1882
HENRY LAPORTE, Esq., M.E., 80, Rue Royale, Brussels		1877
NATHAN MILLER, Esq.		1878
H. J. MORTON, Esq., 4, Royal Crescent, Scarborough	1856	1861
RUDOLPH NASSE, Esq., Konigl Bergwerks Director, Louisenthal, Saarbrücken	1869	1880
ARTHUR PEASE, Esq., M.P., Darlington		1882
W. A. POTTER, Esq., Cramlington House, Northumberland ...	1853	1874
R. CLIFFORD SMITH, Esq., Parkfield, Swinton, Manchester ...		1874
T. H. WARD, Esq., Manager, Kuldiha Colliery, Bengal Coal Co., Limited, Giridi, East Indian Railway, Bengal, India		1882

* Honorary Members during term of office only.

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OFFICERS, 1883-84.

President.

GEORGE BAKER FORSTER, Esq., M.A., Lesbury, R.S.O., Northumberland.

Vice-Presidents.

WM. ARMSTRONG, Esq., Pelaw House, Chester-le-Street.
JOHN DAGLISH, Esq., Marsden, South Shields.
THOMAS DOUGLAS, Esq., Peases' West Collieries, Darlington.
JOHN MARLEY, Esq., Thornfield, Darlington.
J. B. SIMPSON, Esq., Hedgefield House, Blaydon-on-Tyne.
A. L. STEAVENSON, Esq., Durham.

Council.

T. W. BENSON, Esq., 11, Newgate Street, Newcastle-on-Tyne.
R. F. BOYD, Esq., Moor House, Leamside, Fence Houses.
WM. COCHRANE, Esq., Grainger Street West, Newcastle-on-Tyne.
S. C. CRONE, Esq., Killingworth Hall, Newcastle-on-Tyne.
R. FORSTER, Esq., South Hetton, Fence Houses.
W. H. HEDLEY, Esq., Medomsley, Newcastle-on-Tyne.
THOS. HEPPELL, Esq., Leafield House, Chester-le-Street.
T. G. HURST, Esq., F.G.S., Lauder Grange, Corbridge-on-Tyne.
H. LAWRENCE, Esq., Grange Iron Works, Durham.
H. LAWS, Esq., Grainger Street West, Newcastle-on-Tyne.
GEO. MAY, Esq., Harton Colliery Offices, near South Shields.
R. S. NEWALL, Esq., Ferndene, Gateshead-on-Tyne.
M. W. PARRINGTON, Esq., Wearmouth Colliery, Sunderland.
A. M. POTTER, Esq., Shire Moor Colliery, Northumberland.
H. RICHARDSON, Esq., Backworth Colliery, Newcastle-on-Tyne.
R. ROBINSON, Esq., Howlish Hall, near Bishop Auckland.
J. G. WEEKS, Esq., Bedlington Collieries, Bedlington.
W. H. WOOD, Esq., Coxhoe Hall, Coxhoe, Durham.

Ex-officio

- Sir GEORGE ELLIOT, Bart., M.P., Houghton Hall, Fence Houses. — Past Presidents.
- E. F. BOYD, Esq., Moor House, Leamside, Fence Houses. — Past Presidents.
- Sir W. G. ARMSTRONG, C.B., LL.D., F.R.S., Jesmond, Newcastle-on-Tyne. — Past Presidents.
- LINDSAY WOOD, Esq., Southill, Chester-le-Street. — Past Presidents.
- G. C. GREENWELL, Esq., F.G.S., Elm Tree Lodge, Duffield, Derby. — Past Presidents.

- CUTHBERT BERKLEY, Esq., Marley Hill, Gateshead. — Retiring Vice-Presidents.
- T. J. BEWICK, Esq., Haydon Bridge, Northumberland. — Retiring Vice-Presidents.

Secretary and Treasurer.

THEO. WOOD BUNNING, Neville Hall, Newcastle-on-Tyne.

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List of Members.

AUGUST, 1883.

Original Members.

Marked (*) are Life Members.

		ELECTED.
1	ADAMS, G. F., Guild Hall Chambers, Cardiff	Dec. 6, 1873
2	ADAMS, W., Cambridge House, Park Place, Cardiff	1854
3	ADAMSON, DANIEL, Engineering Works, Dukinfield, near Manchester	Aug. 7, 1875
4	AITKIN, HENRY, Falkirk, N.B.	Mar. 2, 1865
5	ALLISON, T., Belmont Mines, Guisbro'	Feb. 1, 1868
6	ANDERSON, C. W., Cleadon House, Harrogate	Aug. 21, 1852
7	ANDERSON, WILLIAM, Rainton Colliery, Fence Houses	Aug. 21, 1852
8	ANDREWS, HUGH, Felton Park, Felton, Northumberland	Oct. 5, 1872
9	APPLEBY, C. E., Charing Cross Chambers, Duke St., Adelphi, London	Aug. 1, 1861
10	ARCHER, T., Dunston Engine Works, Gateshead	July 2, 1872
11	ARMSTRONG, SIR W. G., C.B., LL.D., F.R.S., Jesmond, Newcastle-upon-Tyne ... ... (PAST PRESIDENT, *Member of Council*)	May 3, 1866
12	ARMSTRONG, WM., Pelaw House, Chester-le-Street (VICE-PRESIDENT)	Aug. 21, 1852
13	ARMSTRONG, W., Junior, Wingate, Co. Durham	April 7, 1867
14	ARMSTRONG, W. L., Kettlebrook Colliery, Tamworth	Mar. 3, 1864
15	ARTHUR, DAVID, M.E., Accrington, near Manchester	Aug. 4, 1877
16	ASHWORTH, JAMES, Mapperley Colliery, West Hallam, Derby ...	Feb. 5, 1876
17	ASHWORTH, JOHN, Hanover Chambers, King Street, Manchester ...	Sept. 2, 1876
18	ASQUITH, T. W., Seaton Delaval Colliery, Northumberland	Feb. 2, 1867
19	ATKINSON, J. B., Ridley Mill, Stocksfield-on-Tyne	Mar. 5, 1870
20	ATKINSON, W. N., Shincliffe Hall, Durham	June 6, 1868
21	AUBREY, R. C., Wigan Coal & Iron Co. Ld., Standish, near Wigan ...	Feb. 5, 1870
22	AUSTINE, JOHN, Cadzow Coal Co., Glasgow	Nov. 4, 1876
23	AYNSLEY, WM., Brynkinalt Collieries, Chirk, Ruabon	Mar. 3, 1873
24	BAILES, GEORGE, Murton Colliery, Sunderland	Feb. 3, 1877
25	BAILES, JOHN, Wingate Colliery, Ferryhill	Sept. 5, 1868
26	BAILES, T., 6, Collingwood Terrace, Jesmond Gardens, Newcastle ...	Oct. 7, 1858
27	BAILES, W., West Melton, Rotherham	April 7, 1877
28	BAILEY, SAMUEL, Perry Barr, Birmingham	June 2, 1859
29	BAIN, R. DONALD, Newport, Monmouthshire	Mar. 3, 1873

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ELECTED.

30 BAINBRIDGE, E., Nunnery Colliery Offices, Sheffield ... ... Dec. 3, 1863
31 BANKS, THOMAS, Leigh, near Manchester ... ... Aug. 4, 1877
32 BARCLAY, A., Caledonia Foundry, Kilmarnock ... ... Dec. 6, 1866
33 BARNES, T., Seaton Delaval Office, Quay, Newcastle-on-Tyne ... Oct. 7, 1871
34 BARRAT, A. J., Ruabon Coal Co., Ruabon ... ... Sept. 11, 1875
35 BARTHOLOMEW, C., Castle Hill House, Ealing, London, W. ... ... Aug. 5, 1853
36* BARTHOLOMEW, C. W., Blakesley Hall, near Towcester ... ... Dec. 4, 1875
37 BASSETT, A., Tredegar Mineral Estate Office, Cardiff 1854
38 BATES, MATTHEW, Bews Hill, Blaydon-on-Tyne ... ... Mar. 3, 1873
39 BATES, W. J., Old Axwell, Whickham, Gateshead-on-Tyne ... ... Mar. 3, 1873
40 BATEY, JOHN, Newbury Collieries, Coleford, Bath ... ... Dec. 5, 1868
41 BEANLANDS, A., M.A., North Bailey, Durham ... ... Mar. 7, 1867
42 BEAUMONT, JAMES, M.E., Nanaimo, Vancouver's Island ... ... Nov. 7, 1874
43 BELL, I. LOWTHIAN, Rounton Grange, Northallerton ... ... July 6, 1854
44 BELL, JOHN, Messrs. Bell Brothers, Middlesbro'-on-Tees ... ... Oct. 1, 1857
45 BELL, T., Jun., Messrs. Bell Brothers, Middlesbro'-on-Tees ... ... Mar. 7, 1867
46 BENSON, J. G., Accountant, 12, Grey Street, Newcastle-on-Tyne .. Nov. 7, 1874
47 BENSON, T. W., 11, Newgate Street, Newcastle *(Member of Council)* Aug. 2, 1866
48 BERKLEY, C., Marley Hill Colliery, Gateshead *(Member of Council)* Aug. 21, 1852
49 BEWICK, T. J., M. Inst. C.E., F.G.S., Haydon Bridge, Northumberland *(Member of Council)* April 5, 1860
50 BIDDER, B. P., Dashwood House, London, E.C. ... ... May 2, 1867
51 BIGLAND, J., Bedford Lodge, Bishop Auckland ... ... June 4, 1857
52 BINNS, C., Claycross, Derbyshire ... ... July 6, 1854
53 BIRAM, B., Peaseley Cross Collieries, St. Helen's, Lancashire ... 1856
54 BLACK, JAMES, Jun., Portobello Foundry, Sunderland ... ... Sept. 2, 1871
55 BLACK, W., Hedworth Villa, South Shields ... ... April 2, 1870
56 BOLTON, H. H., Newchurch Collieries, near Manchester ... ... Dec. 5, 1868
57 BOOTH, R. L., Ashington Colliery, near Morpeth 1864
58 BOURNE, THOS. W., 18, Hereford Square, London, S.W. ... ... Sept. 11, 1875
59 BOYD, E. F., Moor House, Leamside, Fence Houses (PAST PRESIDENT, *Member of Council*) ... ... Aug. 21, 1852
60 BOYD, R. F., Moor House, Leamside, Fence Houses *(Mem. of Council)* Nov. 6, 1869
61 BOYD, WM., 74, Jesmond Road, Newcastle-on-Tyne ... ... Feb. 2, 1867
62 BRECKON, J. R., 32, Fawcett Street, Sunderland ... ... Sept. 3, 1864
63 BRETTELL, T., Mine Agent, Dudley, Worcestershire ... ... Nov. 3, 1866
64 BROMILOW, WM., 18, Leicester Street, Southport, Lancashire ... Sept. 2, 1876
65 BROWN, JOHN, Priory Place, 155, Bristol Road, Birmingham ... Oct. 5, 1854
66 BROWN, J. N., 56, Union Passage, New Street, Birmingham ... 1861
67 BROWN, THOS. FORSTER, Guild Hall Chambers, Cardiff 1861
68 BROWNE, B. C., M.I.C.E., 2, Granville Road, Jesmond, Newcastle ... Oct. 1, 1870
69 BRYHAM, WILLIAM, Rosebridge Colliery, Wigan ... ... Aug. 1, 1861
70 BRYHAM, W., Jun., Douglas Bank Collieries, Wigan ... ... Aug. 3, 1865
71 BUNNING, THEO. WOOD, Neville Hall, Newcastle-on-Tyne *(Secretary and Treasurer)* 1864
72* BURNS, DAVID, C.E., Clydesdale Bank Buildings, Bank St., Carlisle... May 5, 1877
73 BURROWS, J. S., Yew Tree House, Atherton, near Manchester ... Oct. 11, 1873

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ELECTED.

74 CAMPBELL, W. B., Consulting Engineer, Grey Street, Newcastle ... Oct. 7, 1876
75 CARR, WM. COCHRAN, South Benwell, Newcastle-on-Tyne ... ... Dec. 3, 1857
76 CHADBORN, B. T., Pinxton Collieries, Alfreton, Derbyshire 1864
77 CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield ... ... Mar. 6, 1869
78 CHAPMAN, M., Dipton, Lintz Green, Newcastle-on-Tyne ... ... Aug. 1, 1868
79 CHEESMAN, I., Throckley Colliery, Newcastle-on-Tyne ... ... Feb. 1, 1873
80 CHEESMAN, W. T., Wire Rope Manufacturer, Hartlepool ... ... Feb. 5, 1876
81 CHILDE, ROWLAND, Wakefield, Yorkshire ... ... May 15, 1862
82 CLARENCE, THOMAS, 10, Bentinck Crescent, Newcastle-on-Tyne ... Dec. 4, 1875
83 CLARK, C. F., Garswood Coal and Iron Co., near Wigan ... ... Aug. 2, 1866
84 CLARK, R. B., Marley Hill, near Gateshead ... ... May 3, 1873
85 CLARK, W., M.E., The Grange, Teversall, near Mansfield ... ... April 7, 1866
86 CLARKE, WILLIAM, Victoria Engine Works, Gateshead ... ... Dec. 7, 1867
87 COCHRANE, B., Aldin Grange, Durham ... ... Dec. 6, 1866
88 COCHRANE, C., The Grange, Stourbridge ... ... June 3, 1857
89 COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle *(Member of Council)* 1859
90 COLE, RICHARD, Walker Colliery, near Newcastle-on-Tyne ... ... April 5, 1873
91 COLE, ROBERT HEATH, Scholar Green, Stoke-upon-Trent ... ... Feb. 5, 1876
92 COLLIS, W. B., Swinford House, Stourbridge, Worcestershire ... June 6, 1861
93 COOK, J., Jun., Washington Iron Works, Gateshead ... ... May 8, 1869
94 COOKE, JOHN, 3, Cross Street, Durham ... ... Nov. 1, 1860
95 COOKSEY, JOSEPH, West Bromwich, Staffordshire ... ... Aug. 3, 1865
96 COOPER, P., Thornley Colliery Office, Ferryhill... ... ... Dec. 3, 1857
97 COOPER, R. E., C.E., 1, Westminster Chambers, Victoria Street, London Mar. 4, 1871
98 COOPER, T., Rosehill, Rotherham, Yorkshire ... ... April 2, 1863
99 COPE, JAMES, Port Vale, Longport, Staffordshire ... ... Oct. 5, 1872
100 CORBETT, V. W., Chilton Moor, Fence Houses ... ... Sept. 3, 1870
101 CORBITT, M., Wire Rope Manufacturer, Teams, Gateshead ... ... Dec. 4, 1875
102 COULSON, F., 10, Victoria Terrace, Durham ... ... Aug. 1, 1868
103 COULSON, W., 32, Crossgate, Durham ... ... Oct. 1, 1852
104 COWEN, JOS., M.P., Blaydon Burn, Newcastle-on-Tyne ... ... Oct. 5, 1854
105 COWEY, JOHN, Wearmouth Colliery, Sunderland ... ... Nov. 2, 1872
106 COWLISHAW, J., Thorncliffe, &c., Collieries, near Sheffield ... ... Mar. 7, 1867
107 COX, JOHN H., 10, St. George's Square, Sunderland ... ... Feb. 6, 1875
108*COXE, E. B., Drifton, Jeddo, P. O. Luzerne Co., Penns., U.S. ... Feb. 1, 1873
109 COXON, S. B., 23, Great George Street, Westminster, London ... June 5, 1856
110 CRAIG, W. Y., Palace Chambers, St. Stephen's, Westminster, London Nov. 3, 1866
111 CRAWFORD, T., Littletown Colliery, near Durham ... ... Aug. 21, 1852
112 CRAWFORD, T., 3, Grasmere Street, Gateshead-on-Tyne ... ... Sept. 3, 1864
113 CRAWFORD, T., Jun. Littletown Colliery, near Durham ... ... Aug. 7, 1869
114 CRAWSHAY, E., Gateshead-on-Tyne ... ... Dec. 4, 1869
115 CRAWSHAY, G., Gateshead-on-Tyne ... ... Dec. 4, 1869
116 CRONE, E. W., Killingworth Hall, near Newcastle-on-Tyne ... ... Mar. 5, 1870
117 CRONE, J. R., Tudhoe House, *via* Spennymoor ... ... Feb. 1, 1868
118 CRONE, S. C., Killingworth Hall, Newcastle *(Member of Council)* ... 1853
119 CROSS, JOHN, 77, King Street, Manchester ... ... June 5, 1869

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ELECTED.

120 CROUDACE, C. J., Bettisfield Colliery Co., Limited, Bagillt, N. Wales — Nov. 2, 1872
121 CROUDACE, JOHN, West House, Haltwhistle ... ... — June 7, 1873
122 CROUDACE, THOMAS, Lambton Lodge, New South Wales ... ... — 1862

123 DAGLISH, JOHN, Marsden, South Shields ... (VICE-PRESIDENT) — Aug. 21, 1852
124 DAGLISH, W. S., Solicitor, Newcastle-on-Tyne ... ... — July 2, 1872
125 DAKERS, J., Chilton Colliery, Ferryhill ... ... — April 11, 1874
126 DALE, DAVID, West Lodge, Darlington ... ... — Feb. 5, 1870
127 D'ANDRIMONT, T., Liége, Belgium ... ... — Sept. 3, 1870
128 DANIEL, W., Steam Plough Works, Leeds ... ... — June 4, 1870
129 DARLING, FENWICK, South Durham Colliery, Darlington ... ... — Nov. 6, 1875
130 DARLINGTON, JAMES, Black Park Colliery Co. Limited, Ruabon ... — Nov. 7, 1874
131 DARLINGTON, JOHN, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London ... ... — April 1, 1865
132 DAVEY, HENRY, C.E., Leeds ... ... — Oct. 11, 1873
133 DAVIS, DAVID, Coal Owner, Maesyffynon, Aberdare ... ... — Nov. 7, 1874
134 DAY, W. H., Eversley Garth, So. Milford ... ... — Mar. 6, 1869
135 DEES, R. R., Solicitor, Newcastle-on-Tyne ... ... — Oct. 7, 1871
136 DICKINSON, G. T., 14, Claremont Place, Newcastle-on-Tyne ... ... — July 2, 1872
137 DICKINSON, R., Coal Owner, Shotley Bridge, Co. Durham ... ... — Mar. 4, 1871
138 DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea ... — Nov. 2, 1872
139 DIXON, NICH., Dudley Colliery, Dudley, Northumberland ... ... — Sept. 1, 1877
140 DIXON, R., Wire Rope Manufacturer, Teams, Gateshead ... ... — June 5, 1875
141 DODD, B., Bearpark Colliery, near Durham ... ... — May 3, 1866
142 DODDS, JOSEPH, M.P., Stockton-on-Tees ... ... — Mar. 7, 1874
143 DOUGLAS, C. P., Parliament Street, Consett, Co. Durham ... ... — Mar. 6, 1869
144 DOUGLAS, T., Peases' West Collieries, Darlington (VICE-PRESIDENT) — Aug. 21, 1852
145 DOVE, G., Viewfield, Stanwix, Carlisle ... ... — July 2, 1872
146 DOWDESWELL, H., Butterknowle Colliery, *via* Darlington ... ... — April 5, 1873
147 DYSON, GEORGE, Middlesbrough ... ... — June 2, 1866
148 DYSON, O., Pooley Hall Colliery, near Tamworth ... ... — Mar. 2, 1872

149 EASTON, J., Nest House, Gateshead ... ... — 1853
150 EDDISON, ROBERT W., Steam Plough Works, Leeds ... ... — Mar. 4, 1876
151 ELLIOT, SIR GEORGE, Bart., M.P., Houghton Hall, Fence Houses (PAST PRESIDENT, *Member of Council*) — Aug. 21, 1852
152 ELSDON, ROBERT, 76, Manor Road, Upper New Cross, London ... — Nov. 4, 1876
153 EMBLETON, T. W., The Cedars, Methley, Leeds ... ... — Sept. 6, 1855
154 EMBLETON, T. W., Jun., The Cedars, Methley, Leeds ... ... — Sept. 2, 1865
155 EMINSON, J. B., Londonderry Offices, Seaham Harbour ... ... — Mar. 2, 1872
156 EVERARD, I. B., M.E., 6, Millstone Lane, Leicester ... ... — Mar. 6, 1869

157 FARMER, A., South Durham Fitting Offices, West Hartlepool ... — Mar. 2, 1872
158 FARRAR, JAMES, Old Foundry, Barnsley ... ... — July 2, 1872
159 FAVELL, THOMAS M., Etruria Iron Works, near Stoke-on-Trent ... — April 5, 1873
160 FENWICK, BARNABAS, 84, Osborne Road, Newcastle-on-Tyne ... — Aug. 2, 1866

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ELECTED.

161 FENWICK, GEORGE, Banker, Newcastle-on-Tyne ... ... Sept. 2, 1871
162 FERENS, ROBINSON, Oswald Hall, near Durham ... ... April 7, 1877
163 FIDLER, E., Platt Lane Colliery, Wigan, Lancashire ... ... Sept. 1, 1866
164 FISHER, R. C., 5, Picton Place, Swansea ... ... July 2, 1872
165 FLETCHER, GEO., Castle Eden Colliery, Co. Durham ... ... Aug. 1, 1874
166 FLETCHER, H., Ladyshore Coll., Little Lever, Bolton, Lancashire ... Aug. 3, 1865
167 FLETCHER, JAS., Manager Co-operative Collieries, Wallsend, near Newcastle, New South Wales ... ... Sept. 11, 1875
168 FLETCHER, W., Lansdowne House, Didsbury, Manchester ... ... Feb. 4, 1871
169 FOGGIN, WM., North Biddick Coll., Washington Station, Co. Durham Mar. 6, 1875
170 FORREST, J., Assoc. Inst. C.E., Witley Coll., Halesowen, Birmingham Mar. 5, 1870
171 FORSTER, G. B., M.A., Lesbury, R.S.O., Northumberland (PRESIDENT) Nov. 5, 1852
172 FORSTER, J. R., Water Company's Office, Newcastle-on-Tyne ... July 2, 1872
173 FORSTER, J. T., Burnhope Colliery, near Lanchester, Co. Durham ... Aug. 1, 1868
174 FORSTER, R., South Hetton, Fence Houses *(Member of Council)* Sept. 5, 1868
175 FOSTER, GEORGE, Osmondthorpe Colliery, near Leeds ... ... Mar. 7, 1874
176 FRANCE, FRANCIS, St. Helen's Colliery Co. Ld., St. Helen's, Lancashire Sept. 1, 1877
177 FRANCE, W., Lofthouse Mines, Saltburn-by-the-Sea ... ... April 6, 1867
178 FRANKS, GEORGE, Victoria Garesfield, Lintz Green, Newcastle-on-Tyne Feb. 6, 1875

179 GALLOWAY, R. L., Ryton-on-Tyne ... ... Dec. 6, 1873
180 GALLOWAY, T. LINDSAY, M.A., Argyle Colliery, Campbeltown, N.B. Sept. 2, 1876
181 GERRARD, JOHN, Westgate, Wakefield ... ... Mar. 5, 1870
182 GILLETT, F. C., Midland Road, Derby ... ... July 4, 1861
183 GILMOUR, D., Portland Colliery, Kilmarnock ... ... Feb. 3, 1872
184 GILPIN, EDWIN, 75, Birmingham Street, Halifax, Nova Scotia ... April 5, 1873
185 GILROY, G., Ince Hall Colliery, Wigan, Lancashire ... ... Aug. 7, 1856
186 GILROY, S. B., Mining Engineer, Cheatham Hill, Manchester ... Sept. 5, 1868
187 GJERS, JOHN, Southfield Villas, Middlesbro' ... ... June 7, 1873
188 GODDARD, F. R., Accountant, Newcastle-on-Tyne ... ... Nov. 7, 1874
189 GORDON, JAMES N., c/o W. Nicolson, 5, Jeffrey's Square, St. Mary Axe, London, E.C. ... ... Nov. 6, 1875
190 GRACE, E. N., Dhadka, Assensole, Bengal, India ... ... Feb. 1, 1868
191 GRANT, J. H., District Engineer, Beerbhoon, Bengal, India ... ... Sept. 4, 1869
192 GREAVES, J. O., M.E., St. John's, Wakefield ... ... Aug. 7, 1862
193 GREEN, J. T., Mining Engineer, Ty Celyn, Abercarn, Newport, Mon. Dec. 3, 1870
194 GREEN, W., Thornelly House, Lintz Green, Newcastle-on-Tyne ... Feb. 4 1853
195 GREENER, JOHN, General Manager, Vale Coll., Pictou, Nova Scotia ... Feb. 6, 1875
196 GREENWELL, G. C., Elm Tree Lodge, Duffield, Derby (PAST PRESIDENT, *Member of Council)* ... ... Aug. 21, 1852
197 GREENWELL, G. C., Jun., Poynton, near Stockport ... ... Mar. 6, 1869
198 GREIG, D., Leeds ... ... Aug. 2, 1866
199 GREY, C. G., 55, Parliament Street, London ... ... May 4, 1872
200 GRIEVES, D., Brancepeth Colliery, Willington, County Durham ... Nov. 7, 1874
201 GRIFFITH, N. R., Wrexham 1866
202 GRIMSHAW, E. J., 23, Hardshaw Street, St. Helen's, Lancashire ... Sept. 5, 1868

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203 HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland ... Mar. 4, 1876
204 HAGGIE, P., Gateshead 1854
205* HAGUE, ERNEST, Castle Dyke, Sheffield ... ... Mar. 2, 1872
206 HAINES, J. RICHARD, Adderley Green Colliery, near Longton ... Nov. 7, 1874
207 HALES, C., Nerquis Cottage, Nerquis, near Mold, Flintshire 1865
208 HALL, F. W., 1, Eslington Terrace, Jesmond Road, Newcastle-on-Tyne Aug. 7, 1869
209 HALL, M., Lofthouse Station Collieries, near Wakefield ... ... Sept. 5, 1863
210 HALL, M. S., M.E., Leasingthorne Colliery, near Bishop Auckland ... Feb. 14, 1874
211 HALL, WM., East Hetton Colliery Office, Coxhoe, Co. Durham ... Dec. 4, 1875
212 HALL, WILLIAM F., Haswell Colliery, Fence Houses ... ... May 13, 1858
213 HANN, EDMUND, Aberaman, Aberdare ... ... Sept. 5, 1868
214 HARBOTTLE, W. H., Orrell Colliery, near Wigan ... ... Dec. 4, 1875
215 HARDY, JOS. ... ... June 2, 1877
216 HARGREAVES, WILLIAM, Rothwell Haigh, Leeds ... ... Sept. 5, 1863
217 HARLE, RICHARD, Browney Colliery, Durham ... ... April 7, 1877
218 HARLE, WILLIAM, Pagebank Colliery, near Durham ... ... Oct. 7, 1876
219 HARRISON, R., Eastwood, near Nottingham 1861
220 HARRISON, T., Cambria Villa, Pontypridd, Glamorganshire ... ... Aug. 2, 1873
221 HARRISON, T. E., C.E., Central Station, Newcastle-on-Tyne ... ... May 6, 1853
222 HARRISON, W. B., Brownhills Collieries, near Walsall ... ... April 6, 1867
223 HASWELL, G. H., Messrs. Tangye Brothers, Birmingham ... ... Mar. 2, 1872
224 HAY, J., Jun., Widdrington Colliery, Acklington ... ... Sept. 4, 1869
225 HECKELS, MATTHEW, Castle Eden Colliery, Co. Durham ... ... April 11, 1874
226 HECKELS, W. J., Evenwood, Bishop Auckland ... ... May 2, 1868
227 HEDLEY, J. J., Consett Collieries, Leadgate, County Durham ... April 6, 1872
228 HEDLEY, J. L., Flooker's Brook, Chester ... ... Feb. 5, 1870
229 HEDLEY, T. F., Valuer, Sunderland ... ... Mar. 4, 1871
230 HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne *(Member of Council)* 1864
231 HENDERSON, H., Pelton Colliery, Chester-le-Street ... ... Feb. 14, 1874
232 HEPPELL, T., Leafield House, Birtley, Chester-le-Street *(Member of Council)* ... ... Aug. 6, 1863
233 HEPPELL, W., Western Hill, Durham ... ... Mar. 2, 1872
234 HERDMAN, J., Park Crescent, Bridgend, Glamorganshire ... ... Oct. 4, 1860
235 HESLOP, C., Lingdale Mines, *via* Skelton, R.S.O., Yorks. ... ... Feb. 1, 1868
236 HESLOP, GRAINGER, Whitwell Colliery, Sunderland ... ... Oct. 5, 1872
237 HESLOP, J., Hucknall Torkard Colliery, near Nottingham ... ... Feb. 6, 1864
238 HETHERINGTON, D., Coxlodge Colliery, Newcastle-on-Tyne 1859
239* HEWITT, G. C., Coal Pit Heath Colliery, near Bristol ... ... June 3, 1871
240 HEWLETT, A., Haigh Colliery, Wigan, Lancashire ... ... Mar. 7, 1861
241 HIGSON, JACOB, 94, Cross Street, Manchester 1861
242 HILTON, J., Wigan Coal and Iron Co., Limited, Wigan ... ... Dec. 7, 1867
243 HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan ... ... Aug. 3, 1865
244 HINDMARSH, THOMAS, Cowpen Lodge, Blyth, Northumberland ... Sept. 2, 1876
245 HODGSON, J. W., Dipton Colliery, *via* Lintz Green Station ... ... Feb. 5, 1870
246 HOLLIDAY, MARTIN, M.E., Peases' West Collieries, Crook ... ... May 1, 1875
247 HOLMES, C., Grange Hill, near Bishop Auckland ... ... April 11, 1874

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248 HOMER, CHARLES J., Mining Engineer, Stoke-on-Trent ... ... Aug. 3, 1865
249 HOOD, A., 6, Bute Crescent, Cardiff ... ... April 18, 1861
250 HOPE, GEORGE, Newbottle Colliery, Fence Houses ... ... Feb. 3, 1877
251 HORNSBY, H., Hamsteels Colliery, near Durham ... ... Aug. 1, 1874
252 HORSLEY, W., Whitehill Point, Percy Main, Newcastle-on-Tyne ... Mar. 5, 1857
253 HOSKOLD, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c. ... April 1, 1871
254 HOWARD, W. F., 13, Cavendish Street, Chesterfield ... ... Aug. 1, 1861
255 HUDSON, JAMES, Albion Mines, Pictou, Nova Scotia 1862
256 HUMBLE, JOHN, West Pelton, Chester-le-Street ... ... Mar. 4, 1871
257 HUMBLE, JOS., Staveley Works, near Chesterfield ... ... June 2, 1866
258 HUNTER, J., Silkstone and Worsbro' Park Collieries, near Barnsley ... Mar. 6, 1869
259 HUNTER, W., Monk Bretton Colliery, near Barnsley ... ... Oct. 3, 1861
260 HUNTER, WM., 34, Grey Street, Newcastle-on-Tyne ... ... Aug. 21, 1852
261 HUNTER, W. S., 34, Grey Street, Newcastle-on-Tyne ... ... Feb. 1, 1868
262 HUNTING, CHARLES, Fence Houses ... ... Dec. 6, 1866
263 HURST, T. G., F.G.S., Lauder Grange, Corbridge-on-Tyne *(Member of Council)* ... ... Aug. 21, 1852

264 JACKSON, C. G., Chamber Colliery Co., Limited, Hollinwood .. ... June 4, 1870
265 JACKSON, W., Cannock Chase Collieries, Walsall ... ... Feb. 14, 1874
266 JACKSON, W. G., Loscoe Grange, Normanton, Yorkshire ... ... June 7, 1873
267 JARRATT, J., Houghton Main Colliery, near Barnsley ... ... Nov. 2, 1867
268 JEFFCOCK, T. W., 18, Bank Street, Sheffield ... ... Sept. 4, 1869
269 JENKINS, W., M.E., Ocean S.C. Colls., Ystrad, nr. Pontypridd, So. Wales Dec. 6, 1862
270 JENKINS, WM., Consett Iron Works, Consett, Durham ... ... May 2, 1874
271 JOHNSON, HENRY, Dudley, Worcestershire ... ... Aug. 7, 1869
272 JOHNSON, JOHN, M. Inst. C.E., F.G.S., 21, Grainger Street West, Newcastle-on-Tyne ... ... Aug. 21, 1852
273 JOHNSON, J., Carlton Main Colliery, Barnsley ... ... Mar. 7, 1874
274 JOHNSON, R. S., Sherburn Hall, Durham ... ... Aug. 21, 1852
275 JOICEY, J. G., Forth Banks West Factory, Newcastle-on-Tyne ... April 10, 1869
276 JOICEY, W. J., Urpeth Lodge, Chester-le-Street ... ... Mar. 6, 1869
277 JOSEPH, D. D., Ty Draw, Pontypridd, South Wales ... ... April 6, 1872

278 KENDALL, JOHN D., Roper Street, Whitehaven ... ... Oct. 3, 1874
279 KIMPTON, J. G., 40, St. Mary's Gate, Derby ... ... Oct. 5, 1872
280 KIRKBY, J. W., Ashgrove, Windygates, Fife ... ... Feb. 1, 1873
281 KIRSOPP, JOHN, Team Colliery, Gateshead ... ... April 5, 1873
282 KNOWLES, A., High Bank, Pendlebury, Manchester ... ... Dec. 5, 1856
283 KNOWLES, JOHN, Westwood, Pendlebury, Manchester ... ... Dec. 5, 1856
284 KNOWLES, THOMAS, Ince Hall, Wigan ... ... Aug. 1, 1861
285 KYRKE, R. H. V., Westminster Chambers, Wrexham ... ... Feb. 5, 1870

286 LAMB, R., Bowthorn Colliery, Cleator Moor, near Whitehaven ... Sept. 2, 1865
287 LAMB, R. O., The Lawn, Ryton-on-Tyne ... ... Aug. 2, 1866
288 LAMB, RICHARD W., Coal Owner, Newcastle-on-Tyne... ... ... Nov. 2, 1872
289 LAMBERT, M. W., 9, Queen Street, Newcastle-on-Tyne ... ... July 2, 1872

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290 LANCASTER, JOHN, Frankfort House, Fitzjohn's Avenue, London, N.W. July 4, 1861
291 LANCASTER, J., Jun., Anfield House, Willes Road, Leamington ... Mar. 2, 1865
292 LANCASTER, S., Nantyglo & Blaina Steam Coal Collieries, Blaina, Mon. Aug. 3, 1865
293 LANDALE, A., Lochgelly Iron Works, Fifeshire, N.B. ... ... Dec. 2, 1858
294* LAPORTE, HENRY, M.E., 80, Rue Royale, Brussels ... ... May 5, 1877
295 LAVERICK, ROBT., West Rainton, Fence Houses ... ... Sept. 2, 1876
296 LAWRENCE, HENRY, Grange Iron Works, Durham *(Mem. of Council)* Aug. 1, 1868
297 LAWS, H., Grainger Street W., Newcastle-on-Tyne *(Mem. of Council)* Feb. 6, 1869
298 LAWS, JOHN, Blyth, Northumberland 1854
299 LEBOUR, G. A., M.A., F.G.S., Durham College of Science, Newcastle Feb. 1, 1873
300 LEE, GEORGE, Great Ayton, *vid* Northallerton ... ... June 4, 1870
301 LESLIE, ANDREW, Hebburn, Gateshead-on-Tyne ... ... Sept. 7, 1867
302 LEVER, ELLIS, Bowdon, Cheshire 1861
303 LEWIS, HENRY, Annesley Colliery, near Nottingham ... ... Aug. 2, 1866
304 LEWIS, W. H., 3, Bute Crescent, Cardiff ... ... Aug. 4, 1877
305 LEWIS, WILLIAM THOMAS, Mardy, Aberdare 1864
306 LIDDELL, G. H., Somerset House, Whitehaven ... ... Sept. 4, 1869
307 LINDOP, JAMES, Bloxwich, Walsall, Staffordshire ... ... Aug. 1, 1861
308 LINSLEY, R., Cramlington Colliery, Northumberland ... ... July 2, 1872
309 LINSLEY, S. W., Whitburn Colliery, Sunderland ... ... Sept. 4, 1869
310 LISHMAN, T., Jun., Hetton Colliery, Fence Houses ... ... Nov. 5, 1870
311 LISHMAN, WM., Witton-le-Wear... 1857
312 LISHMAN, WM., Bunker Hill, Fence Houses ... ... Mar. 7, 1861
313 LIVESEY, C., Bradford Colliery, near Manchester ... ... Aug. 3, 1865
314 LIVESEY, T., Bradford Colliery, near Manchester ... ... Nov. 7, 1874
315 LLEWELYN, L., c/o W. P. James, Abersychan Iron Works, nr. Pontypool May 4, 1872
316 LOGAN, WILLIAM, Langley Park Colliery, Durham ... ... Sept. 7, 1867
317 LONGBOTHAM, J., Norley Collieries, near Wigan ... ... May 2, 1868
318 LONGRIDGE, J. A., 15, Great George Street, Westminster, London, S.W. Aug. 21, 1852
319 LUPTON, A., F.G.S., 4, Albion Place, Leeds ... ... Nov. 6, 1869

320 MADDISON, HENRY, The Lindens, Darlington ... ... Nov. 6, 1875
321 MALING, C. T., Ford Pottery, Newcastle-on-Tyne ... ... Oct. 5, 1872
322 MAMMATT, J. E., C.E., St. Andrew's Chambers, Leeds 1864
323 MARLEY, JOHN, Thornfield, Darlington... ... (VICE-PRESIDENT) Aug. 21, 1852
324 MARLEY, J. W., 7, Victoria Street, Westminster Palace Hotel, Westminster, London, S.W. ... ... Aug. 1, 1868
325 MARSHALL, F. C., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne ... Aug. 2, 1866
326 MARSTON, W. B., Leeswood Vale Oil Works, Mold ... ... Oct. 3, 1868
327 MARTEN, E. B., C.E., Pedmore, near Stourbridge ... ... July 2, 1872
328 MATTHEWS, R. F., Hardwicke, Sedgefield ... ... Mar. 5, 1857
329 MAUGHAN, J. A., Nerbudda Coal and Iron Co. Limited, Garrawarra, Central Provinces, India ... ... Nov. 7, 1863
330 MAY, GEORGE, Harton Colliery Offices, near South Shields *(Member of Council)* ... ... Mar. 6, 1862
331 MCCREATH, J., 95, Bath Street, Glasgow ... ... Mar. 5, 1870
332 MCCULLOCH, DAVID, Beech Grove, Kilmarnock, N.B. ... ... Dec. 4, 1875

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333 McCULLOCH, H. J., 4, Finsbury Circus, London ... ... Oct. 1, 1863
334 McCULLOCH, W., 4, Finsbury Circus, London ... ... Nov. 7, 1874
335 McGHIE, T., Cannock, Staffordshire ... ... Oct. 1, 1857
336 McMURTRIE, J., Radstock Colliery, Bath ... ... Nov. 7, 1863
337 MEIK, THOMAS, C.E., 6, York Place, Edinburgh ... ... June 4, 1870
338 MERIVALE, J. H., 2, Victoria Villas, Newcastle-on-Tyne ... ... May 5, 1877
339 MILLER, ROBERT, Beech Grove, Lock Park, Barnsley ... ... Mar. 2, 1865
340 MILLS, M. H., Duckmanton Lodge, Chesterfield ... ... Feb. 4, 1871
341 MITCHELL, CHAS., Jesmond, Newcastle-on-Tyne ... ... April 11, 1874
342 MITCHELL, JOSEPH, Bolton Hall, Rotherham ... . Feb, 14, 1874
343 MITCHINSON, R., Jun., Pontop Coll., Lintz Green Station, Co. Durham Feb. 4, 1865
344 MOFFAT, T., Montreal Iron Ore Works, Whitehaven ... ... Sept. 4, 1869
345 MONKHOUSE, JOS., 360, Gilcrux, Cockermouth ... ... June 4, 1863
346 MOOR, T., Cambois Colliery, Blyth ... ... Oct. 3, 1868
347 MOOR, WM., Jun., Hetton Colliery, Fence Houses ... ... July 2, 1872
348 MOORE, R. W., Colliery Office, Whitehaven ... ... Nov. 5, 1870
349 MORISON, D. P., 23, Ellison Place, Newcastle-on-Tyne 1861
350 MORRIS, W., Waldridge Colliery, Chester-le-Street 1858
351* MORTON, H. J., 4, Royal Crescent, Scarborough 1861
352 MORTON, H. T., Lambton, Fence Houses ... ... Aug. 21, 1852
353 MOSES, WM., Barmoor Colliery, Beal ... ... Mar. 2, 1872
354 MUCKLE, JOHN, 11, Oxford Terrace, Gateshead-on-Tyne ... ... Mar. 7, 1861
355 MULVANY, W. T., Pempelfort, Dusseldorf-on-the-Rhine ... ... Dec. 3, 1857
356 MUNDLE, ARTHUR, 7, Collingwood Street, Newcastle-on-Tyne ... June 5, 1875
357 MUNDLE, W., Redesdale Mines, Bellingham ... ... Aug. 2, 1873

358* NASSE, RUDOLPH, Konigl Bergwerks Director, Louisenthal, Saarbrücken, Prussia 1869
359 NEVIN, JOHN, Mirfield, Yorkshire ... ... May 2, 1868
360 NEWALL, R. S., Ferndene, Gateshead-on-Tyne *(Member of Council)*... May 2, 1863
361 NICHOLSON, E., jun., Beamish Colliery, Chester-le-Street ... ... Aug. 7, 1869
362 NICHOLSON, MARSHALL, Middleton Hall, Leeds ... ... Nov. 7, 1863
363 NOBLE, CAPTAIN, Jesmond, Newcastle-on-Tyne ... ... Feb. 3, 1866
364 NORTH, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire ... Oct. 6, 1864
365 NUTTALL, THOMAS, Broad Street, Bury, Lancashire ... ... Sept. 11, 1875

366 OGDEN, JOHN M., Solicitor, Sunderland .. .. Mar. 5, 1857
367 OGILVIE, A. GRAEME, 4, Great George Street, Westminster, London Mar. 3, 1877
368 OLIVER, ROBERT, Charlaw Colliery, near Durham ... ... Nov. 6, 1875

369 PACEY, T., Bishop Auckland ... ... April 10, 1869
370 PALMER, A. S., Usworth Hall, Washington Station, Co. Durham ... July 2, 1872
371 PALMER, C. M., M.P., Quay, Newcastle-on-Tyne ... ... Nov. 5, 1852
372 PAMELY, C., Radstock Coal Works, near Bath ... ... Sept. 5, 1868
373 PANTON, F. S., Silksworth Colliery, Sunderland ... ... Oct. 5, 1867
374 PARKIN, C., Hutton-le-Hole, Kirby Moorside, York. ... ... June 5, 1875

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		ELECTED.
375	PARRINGTON, M. W., Wearmouth Colliery, Sunderland *(Member of Council)*	Dec. 1, 1864
376	PARTON, T., F.G.S., Ash Cottage, Birmingham Road, West Bromwich	Oct. 2, 1869
377	PATTISON, JOHN, Engineer, Naples	Nov. 7, 1874
378	PEACE, M. W., Wigan, Lancashire	July 2, 1872
379	PEACOCK, DAVID, West Bromwich	Aug. 7, 1869
380	PEARCE, F. H., Bowling Iron Works, Bradford	Oct. 1, 1857
381	PEASE, Sir J. W., Bart., M.P., Hutton Hall, Guisbro', Yorkshire ...	Mar. 5, 1857
382	PEEL, JOHN, Wharncliffe Silkstone Collieries, near Barnsley ...	Nov. 1, 1860
383	PEEL, JOHN, Horsley Colliery, Wylam-on-Tyne	Mar. 3, 1877
384	PEILE, WILLIAM, Ellerkeld, Stainburn, Workington	Oct. 1, 1863
385	PENMAN, J. H., 2, Clarence Buildings, Booth Street, Manchester ...	Mar. 7, 1874
386	PICKUP, P. W., Rishton, near Blackburn	Feb. 6, 1875
387	PINCHING, ARCHD. E., South Indian Mining Co., Glenock Estate, Devala, Madras Residency, India	May 5, 1877
388	POTTER, ADDISON, C.B., Heaton Hall, Newcastle-on-Tyne	Mar. 6, 1869
389	POTTER, A. M., Shire Moor Coll., Northumberland *(Member of Council)*	Feb. 3, 1872
390	POTTER, C. J., Heaton Hall, Newcastle-on-Tyne	Oct. 3, 1874
391*	POTTER, W. A., Cramlington House, Northumberland	1853
392	PRICE, JOHN, Messrs. Palmer & Co., Limited, Jarrow-on-Tyne ...	Mar. 3, 1877
393	PRICE, J. R., Standish, near Wigan	Aug. 7, 1869
394	PRIESTMAN, JON., Coal Owner, Newcastle-on Tyne	Sept. 2, 1871
395	PRINGLE, EDWARD, Choppington Colliery, Northumberland	Aug. 4, 1877
396	RAMSAY, J. A., Langley Old Hall, near Durham	Mar. 6, 1869
397	RAMSAY, WM., Tursdale Colliery, County Durham	Sept. 11, 1875
398	REED, ROBERT, Felling Colliery, Gateshead	Dec. 3, 1863
399	REES, DANIEL, Glandare, Aberdare	1862
400	REFEEN, WM., Teplitz, Bohemia	Oct. 5, 1872
401	REID, ANDREW, Newcastle-on-Tyne	April 2, 1870
402	RICHARDS, E. W., Messrs. Bolckow, Vaughan, & Co., Middlesbro' ...	Aug. 5, 1876
403	RICHARDSON, H., Backworth Colliery, Newcastle-on-Tyne *(Member of Council)*	Mar. 2, 1865
404	RICHARDSON, J. W., Iron Shipbuilder, Newcastle-on-Tyne	Sept. 3, 1870
405	RIDLEY, G., Trinity Chambers, Newcastle-on-Tyne	Feb. 4, 1865
406	RIDLEY, J. H., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne ...	April 6, 1872
407	RIDYARD, J., Bridgewater Offices, Walkden, nr. Bolton-le-Moors, Lan.	Nov. 7, 1874
408	RITSON, U. A, 6, Queen Street, Newcastle-on-Tyne	Oct. 7, 1871
409	RITSON, W. A., Tamworth Colliery Co., Tamworth	April 2, 1870
410	ROBERTSON, W., M.E., 123, St. Vincent Street, Glasgow	Mar. 5, 1870
411	ROBINSON, G. C., Brereton and Hayes Colls., Rugeley, Staffordshire...	Nov. 5, 1870
412	ROBINSON, JOHN, Hebburn Colliery, near Newcastle-on-Tyne ...	Nov. 4, 1876
413	ROBINSON, R., Howlish Hall, near Bishop Auckland *(Mem. of Council)*	Feb. 1, 1868
414	ROBSON, E., Middlesbro'-on-Tees...	April 2, 1870
415	ROBSON, J. S., Butterknowle Colliery, *via* Darlington...	1853
416	ROBSON, J. T., Cambuslang, Glasgow	Sept. 4, 1869
417	ROBSON, THOMAS, Lumley Colliery, Fence Houses	Oct. 4, 1860

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418 ROGERSON, John, Croxdale Hall, Durham ... ... Mar. 6, 1869
419 ROSCAMP, J., Rosedale Lodge, near Pickering, Yorkshire ... ... Feb. 2, 1867
420 ROSS, J. A. G., Consulting Engineer, 13, Belgrave Terrace, Newcastle July 2, 1872
421 ROSSER, W., Mineral Surveyor, Llanelly, Carmarthenshire 1856
422 ROTHWELL, R. P., 27, Park Place, New York, U.S. ... ... Mar. 5, 1870
423 ROUTLEDGE, Jos., Ryhope Colliery, Sunderland ... ... Sept. 11, 1875
424 ROUTLEDGE, WM., Sydney, Cape Breton ... ... Aug. 6, 1857
425 ROWLEY, J. C., Shagpoint Colliery, Otago, New Zealand ... ... Dec. 4, 1875
426 RUTHERFORD, J., Halifax Coal Co., Ld., Albion Mines, Nova Scotia... 1852
427 RUTHERFORD, W., So. Derwent Colliery, Annfield Plain, Lintz Green Oct. 3, 1874
428 RUTTER, THOS., Blaydon Main Colliery, Blaydon-on-Tyne ... ... May 1, 1875
429 RYDER, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne ... Nov. 4, 1876

430 SAINT, GEORGE, Vauxhall Collieries, Ruabon, North Wales ... ... April 11, 1874
431 SCARTH, W. T., Raby Castle, Darlington ... ... April 4, 1868
432 SCOTT, ANDREW, Broomhill Colliery, Acklington ... ... Dec. 7, 1867
433 SCOTT, C. F., Gateshead Fell Colliery, Gateshead-on-Tyne ... ... April 11, 1874
434 SCOULAR, G., Cleator Moor, *via* Carnforth ... ... July 2, 1872
435 SEDDON, J. F., Great Harwood Collieries, near Accrington ... ... June 1, 1867
436 SHALLS, F. W., Pritchard & Sons, 9, Gracechurch Street, London ... April 6, 1872
437 SHAW, W., Jun., Wolsingham, *via* Darlington ... ... June 3, 1871
438 SHIEL, JOHN, Framwellgate Colliery, County Durham ... ... May 6, 1871
439 SHONE, ISAAC, Pentrefelin House, Wrexham 1858
440 SHORTREDE, T., Park House, Winstanley, Wigan ... ... April 3, 1856
441 SHUTE, C. A., Westoe, South Shields ... ... April 11, 1874
442 SIMPSON, J., Heworth Colliery, near Gateshead-on-Tyne ... ... Dec. 6, 1866
443 SIMPSON, Jos., Springhill Mines, Cumberland Co., Nova Scotia ... Mar. 3, 1873
444 SIMPSON, J. B., Hedgefield House, Blaydon-on-Tyne (VICE-PRESIDENT) Oct. 4, 1860
445 SIMPSON, R., Moor House, Ryton-on-Tyne ... ... Aug. 21, 1852
446 SIMPSON, ROBT., Drummond Coll., Westville, Pictou, Nova Scotia ... Dec. 4, 1875
447 SLINN, T., 2, Choppington Street, Westmorland Road, Newcastle ... July 2, 1872
448 SMALL, G., Duffield Road, Derby .. .. June 4, 1870
449 SMITH, G. F., Grovehurst, Tunbridge Wells ... ... Aug. 5, 1853
450 SMITH, J., Bickershaw Colliery, Leigh, near Manchester ... ... Mar. 7, 1874
451* SMITH, R. CLIFFORD, Parkfield, Swinton, Manchester ... ... Dec. 5, 1874
452 SMITH, T., Sen., M.E., Cinderford Villas, nr. Newnham, Gloucester... May, 5, 1877
453 SMITH, T. E., Phœnix Foundry, Newgate Street, Newcastle-on-Tyne Dec. 5, 1874
454 SNOWDON, T., jun., West Bitchburn Coll., nr. Tow Law, *via* Darlington Sept, 4, 1869
455 SOPWITH, A., Cannock Chase Collieries, near Walsall ... ... Aug. 1, 1868
456 SOPWITH, THOS., 6, Great George St., Westminster, London, S.W. ... Mar. 3, 1877
457 SOUTHERN, R, Burleigh House, The Parade, Tredegarville, Cardiff ... Aug. 3, 1865
458 SOUTHWORTH, THOS., Hindley Green Collieries, near Wigan ... ... May 2, 1874
459 SPENCER, JOHN, Westgate Road, Newcastle-on-Tyne ... ... Sept. 4, 1869
460 SPENCER, M., Newburn, near Newcastle-on-Tyne ... ... Sept. 4, 1869
461 SPENCER, T., Ryton, Newcastle-on-Tyne ... ... Dec. 6, 1866
462 SPENCER, W., Southfields, Leicester ... ... Aug. 21, 1852
463 STEAVENSON, A. L., Durham ... ... (VICE-PRESIDENT) Dec. 6, 1855

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		ELECTED.
464	Stephenson, G. R., 9, Victoria Chambers, Westminster, London, S.W.	Oct. 4, 1860
465	Stevenson, R., Lochgelly Iron Works, Lochgelly, Fifeshire	Feb. 5, 1876
466	Stobart, W., Pepper Arden, Northallerton	July 2, 1872
467	Storey, Thos. E., Clough Hall Iron Works, Kidsgrove, Staffordshire	Feb. 5, 1876
468	Straker, John, Stagshaw House, Corbridge-on-Tyne	May 2, 1867
469	Straker, J. H., Willington House, Co. Durham	Oct. 3, 1874
470	Stratton, T. H. M., Tredegar, South Wales	Dec. 3, 1870
471	Swallow, J., Pontop Hall, Lintz Green, Newcastle-on-Tyne ...	May 2, 1874
472	Swallow, R. T., Springwell, Gateshead-on-Tyne	1862
473	Swan, H. F., Shipbuilder, Newcastle-on-Tyne	Sept. 2, 1871
474	Swan, J. G., Upsall Hall, near Middlesbro'	Sept. 2, 1871
475	Swann, C. G., Sec., General Mining Asso. Ld., 6, New Broad St., London	Aug. 7, 1875
476	Tate, Simon, Trimdon Grange Colliery, Co. Durham	Sept. 11, 1875
477	Taylor, Hugh, King Street, Quay, Newcastle-on-Tyne	Sept. 5, 1856
478	Taylor, T., King Street, Quay, Newcastle-on-Tyne	July 2, 1872
479	Taylor-Smith, Thomas, Greencroft Park, Durham	Aug. 2, 1866
480	Thomas, A., Bilson House, near Newnham, Gloucestershire	Mar. 2, 1872
481	Thompson, John, Boughton Hall, Chester	Sept. 2, 1865
482	Thompson, R., Jun., Redridge House, Wingate, Co. Durham ...	Sept. 7, 1867
483	Thompson, T. C., Milton Hall, Carlisle	May 4, 1854
484	Thomson, John, Eston Mines, by Middlesbro'	April 7, 1877
485	Thomson, Jos. F., Manvers Main Colliery, Rotherham	Feb. 6, 1875
486	Tinn, J., C.E., Ashton Iron Rolling Mills, Bower Ashton, Bristol ...	Sept. 7, 1867
487	Tylden-Wright, C., Shireoaks Colliery, Worksop, Notts.	1862
488	Tyson, Wm. John, 15, Foxhouses Road, Whitehaven	Mar. 3, 1877
489	Tyzack, D., Birtley, Chester-le-Street, Durham	Feb. 14, 1874
490	Tyzack, Wilfred, Tanfield Lea Coll., Lintz Green Station, Newcastle	Oct. 7, 1876
491	Vivian, John, Diamond Boring Company, Whitehaven	Mar. 3, 1877
492	Wadham, E., C. and M.E., Millwood, Dalton-in-Furness	Dec. 7, 1867
493	Walker, G. B., Wharncliffe Silkstone Collieries, Wortley, nr. Sheffield	Dec. 2, 1871
494	Walker, J. S., 15, Wallgate, Wigan, Lancashire	Dec. 4, 1869
495	Walker, W., Saltburn-by-the-Sea	Mar. 5, 1870
496	Wallace, Henry, Trench Hall, Gateshead	Nov. 2, 1872
497	Ward, H., Rodbaston Hall, near Penkridge, Stafford	Mar. 6, 1862
498	Wardale, John D., M.E., Redheugh Engine Works, Gateshead ...	May 1, 1875
499	Wardell, S. C., Doe Hill House, Alfreton	April 1, 1865
500	Warrington, J., Cragwood, Rawdon, near Leeds	Oct. 6, 1859
501	Watson, H., High Bridge Works, Newcastle-on-Tyne	Mar. 7, 1868
502	Watson, H. B., High Bridge Works, Newcastle-on-Tyne	Mar. 3, 1877
503	Watson, M., Flimby and Broughton Moor Collieries, near Maryport..	Mar. 7, 1868
504	Weeks, J. G., Bedlington Collieries, Bedlington *(Member of Council)*	Feb. 4, 1865
505	Westmacott, P. G. B., Elswick Iron Works, Newcastle	June 2, 1866
506	White, H., Weardale Coal Company, Tow Law, near Darlington ...	1866

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		ELECTED.
507	WHITE, J. F., M.E., Wakefield	July 2, 1872
508	WHITE, J. W. H., Woodlesford, near Leeds	Sept. 2, 1876
509	WHITEHEAD, JAMES, Brindle Lodge, near Preston, Lancashire ...	Dec. 4, 1875
510	WHITELAW, JOHN, 118, George Street, Edinburgh	Feb. 5, 1870
511	WHITELAW, T., Shields and Dalzell Collieries, Motherwell	April 6, 1872
512	WHITTEM, THOS. S., Wyken Colliery, near Coventry	Dec. 5, 1874
513	WIDDAS, C., North Bitchburn Colliery, Howden, Darlington... ...	Dec. 5, 1868
514	WIGHT, W. H., Cowpen Colliery, Blyth...	Feb. 3, 1877
515	WILD, J. G., Hedley Hope Collieries, Tow Law, by Darlington ...	Oct. 5, 1867
516	WILLIAMS, E., Cleveland Lodge, Middlesbro'	Sept. 2, 1865
517	WILLIAMS, J. J., Pantgwyn House, Holywell, Flintshire	Nov. 2, 1872
518	WILLIAMSON, JOHN, Cannock, &c., Collieries, Hednesford	Nov. 2, 1872
519	WILLIS, J., 14, Portland Terrace, Newcastle-on-Tyne	Mar. 5, 1857
520	WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton... ...	Nov. 5, 1852
521	WILSON, ROBERT, Flimby Colliery, Maryport	Aug. 1, 1874
522	WILSON, W. B., Kippax and Allerton Collieries, Leeds	Feb. 6, 1869
523	WINTER, T. B., Grey Street, Newcastle-on-Tyne	Oct. 7, 1871
524	WOOD, C. L., Freeland, Bridge of Earn, Perthshire	1853
525	WOOD, LINDSAY, Southill, Chester-le-Street (PAST PRESIDENT, *Member of Council)*	Oct. 1, 1857
526	WOOD, THOMAS, Rainton House, Fence Houses	Sept. 3, 1870
527	WOOD, W. H., Coxhoe Hall, Coxhoe, Co. Durham *(Member of Council)*	1856
528	WOOD, W. O., Durham	Nov. 7, 1863
529	WOOLCOCK, HENRY, St. Bees, Cumberland	Mar. 3, 1873
530	WRIGHT, G. H., 12, Trumpington Street, Cambridge	July 2, 1872
531	WRIGHTSON, T., Stockton-on-Tees	Sept. 13, 1873
532	YOUNG, PHILIP, 84, Bucknall Old Road, Hanley	Oct. 11, 1873

Ordinary Members.

1	ACKROYD, WM., Jun., M.E., Morley Main Collieries, Morley, nr. Leeds	Feb. 7, 1880
2	BELL, C. E., Park House, Durham	Dec. 3, 1870
3	BRAMALL, HENRY, M.I.C.E., St. Helen's, Lancashire	Oct. 5, 1878
4	BROJA, RICHARD, Mining Engineer, Ostwall, Dortmund	Nov. 6, 1880
5	BUTLER, W. F., C.E., Cymman Hall, near Wrexham	Feb. 7, 1880
6	CHARLTON, HENRY, Hawks, Crawshay, & Sons, Gateshead-on-Tyne	Dec. 9, 1882
7	COCHRANE, JOHN E., Con. Engineer, Hetton-le-Hole, Fence Houses...	Dec. 9, 1882
8	DACRES, THOMAS, South Grange, Shincliffe, Durham	May 4, 1878
9*	DIXON, JAMES S., 170, Hope Street, Glasgow	Aug. 3, 1878
10	ELLIS, W. R., F.G.S., Wigan	June 1, 1878
11	GEDDES, GEORGE H., 142 Princes Street, Edinburgh	Oct. 1, 1881
12	GILCHRIST, THOMAS, Eltringham, Prudhoe-on-Tyne	May 4, 1878
13	GOUDIE, J. H., 13, Lowther Street, Whitehaven	Sept. 7, 1878

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14 HARBOTTLE, JOHN, Linlithgow Mines, Columbia Co., New York ... June 10, 1882
15 JOHNSON, HENRY, Jun., Sandwell Park Colliery, West Bromwich, South Staffordshire ... ... Feb. 10, 1883
16 JOHNSON, WILLIAM, West Stanley Colliery, Chester-le-Street ... Dec. 9, 1882
17 KELLETT, WILLIAM, Wigan ... ... June 1, 1878
18 LANCASTER, JOHN, Auchinbeath, Southfield and Fence Collieries, Lesmahagow ... ... Sept. 7, 1878
19 LAWS, W. G., Civil Engineer, Newcastle-on-Tyne ... ... Oct. 2, 1880
20 LEACH, C. C., Bedlington Colls., Bedlington, R.S.O., Northumberland Mar. 7, 1874
21 LIDDELL, MATTHEW, Mickley Colliery Offices, Stocksfield-on-Tyne ... Feb. 10, 1883
22 LLEWELLIN, DAVID MORGAN, F.G.S., Glanwern Offices, Pontypool ... May 14, 1881
23 MARTIN, TOM PATTINSON, Allhallows Colliery, Mealsgate, Carlisle ... Feb. 15, 1879
24 OLDHAM, G. H., St. John D'El Rey Mining Co., Tower Chambers, Finsbury Pavement, London ... ... Aug. 5, 1882
25 POTTS, Jos., Jun., Architect, &c., North Cliff, Roker, Sunderland ... Dec. 6, 1879
26 PRIOR, EDWARD G., Victoria, British Columbia... ... ... Feb. 7, 1880
27 ROGERS, WILLIAM, M.E., 19, King Street, Wigan ... ... Nov. 2, 1878
28 RUSSELL, ROBERT, M.E., Coltness Iron Works, Newmains, N.B. ... Aug. 3, 1878
29 SPENCER, JOHN W., Newburn, near Newcastle-on-Tyne ... ... May 4, 1878
30 TOPPING, WALTER, Messrs. Cross, Tetley, & Co., Platt Bridge, Wigan Mar. 2, 1878
31 WALKER, SIDNEY FERRIS, 195, Severn Road, Canton, Cardiff ... Dec. 9, 1882
32 WALKER, WILLIAM EDWARD, Lowther Street, Whitehaven ... ... Nov. 19, 1881
33 WINSTANLEY, ROBT., M.E., 32, St. Ann's Street, Manchester... ... Sept. 7, 1878

Associate Members.

1 ALLAN, JOHN, 607 Erbische Strasse, Freiberg in Sachsen ... ... Feb. 10, 1883
2 ARMSTRONG, HENRY, M.E., St. Hilda Colliery, South Shields ... April 14, 1883
3 ARMSTRONG, T. J., Hawthorn Terrace, Newcastle-on-Tyne ... ... Feb. 10, 1883
4 ARNOLD, THOS., Mineral Surveyor, Castle Hill, Greenfields, Llanelly Oct. 2, 1880
5 ATKINSON, FRED., Maryport ... ... Feb. 14, 1874
6 AUDUS, T., Mineral Traffic Manager, N.E. Railway, Newcastle-on-Tyne Aug. 7, 1880
7 AYTON, E. F., Heddon Colliery, Wylam-on-Tyne ... ... Feb. 5, 1876

8 BAILES, E. T., Wingate, Ferryhill ... ... June 7, 1879
9 BARNES, A. W., Grassmore Colliery, near Chesterfield ... ... Oct. 5, 1872
10 BARRETT, CHARLES ROLLO, New Seaham, Seaham Harbour ... ... Nov. 7, 1874
11 BATES, C. J., Coal Owner, Heddon Banks, near Wylam-on-Tyne ... Dec. 11, 1882
12* BELL, THOMAS HUGH, Coal Owner, Middlesbrough-on-Tees ... ... Dec. 11, 1882
13 BERKLEY, FREDERICK, M.E., Murton Colliery, near Sunderland ... Dec. 11, 1882
14 BERKLEY, R. W., Marley Hill Colliery, Gateshead ... ... Feb. 14, 1874
15 BEWICK, T. B., Haydon Bridge, Northumberland ... ... Mar. 7, 1874
16 BIRD, W. J., 9, Prince Street, Sunderland ... ... Nov. 6, 1875
17 BOWES, JOHN, Streatlam Castle, Darlington ... ... Feb. 10, 1883

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18	BROUGH, THOMAS, Seaham Colliery, Seaham Harbour	Feb. 1, 1873
19	BROWN, M. W., 7, Elswick Park, Newcastle-on-Tyne	Oct. 7, 1871
20	BROWN, W. B., Springfield, Wavertree, Liverpool	Mar. 2, 1878
21	BRUCE, JOHN, Cannock Chase Colliery, near Walsall	Feb. 14, 1874
22	BULMAN, H. F., West Rainton, Fence Houses	May 2, 1874
23	BUNNING, C. Z., Warora Colliery, Central Provinces, India	Dec. 6, 1873
24	BURDON, A. E., Hartford House, Cramlington, Northumberland ...	Feb. 10, 1883
25	BURN, JOHN H., Coal Owner, 20, Broad Chare, Newcastle-on-Tyne ...	Feb. 10, 1883
26	BURNLEY, C. E., Aybrigg Farm, near Wakefield	April 11, 1874
27	CABRERA, FIDEL, c/o H. Kendall & Son, 12, Gt. Winchester St., London	Oct. 6, 1877
28	CANDLER, T. E., East Lodge, Crook, Darlington	May 1, 1875
29	CHARLTON, W. A., Tangye Bros., 25, Lincoln St., Gateshead-on-Tyne	Nov. 6, 1880
30	CLARK, ROBT., So. Medomsley Coll., Dipton, Lintz Green, nr. Newcastle	Sept. 11, 1875
31	CLOUGH, JAMES, Bedlington Collieries, R.S.O., Northumberland ...	April 5, 1873
32	COBBOLD, C. H., Mineral Office, Elsecar, near Barnsley	May 3, 1873
33	COCHRANE, RALPH D., Hetton Colliery Offices, Fence Houses ...	June 1, 1878
34	COCKSON, CHARLES, King Street, Wigan	April 22, 1882
35	COOPER, R. W., Solicitor, Newcastle-on-Tyne	Sept. 4, 1880
36	DAKERS, W. R., Tudhoe Colliery, Spennymoor	Oct. 14, 1882
37	DALZIEL, W. G., 2, Pembroke Terrace, Cardiff	Sept. 7, 1878
38	DAVISON, CHARLES, Cornsay Colliery, near Esh, Durham	Dec. 11, 1882
39	DODD, M., Lemington, Scotswood-on-Tyne	Dec. 4, 1875
40	DOUGLAS, JOHN, Seghill Colliery, Dudley, Northumberland	April 22, 1882
41	DOUGLAS, JOHN, Jun., Seghill Colliery, Dudley, Northumberland ...	April 22, 1882
42	DOUGLAS, M. H., Marsden Colliery, South Shields	Aug. 2, 1879
43	DOYLE, PATRICK, C.E., F.M.S., F.L.S., M.R.A.S., Municipal Chambers, Charters Towers, *via* Townsville, Queensland, Australia	Mar. 1, 1879
44	EDGE, J. C., Eckington Colliery, near Chesterfield	Dec. 5, 1874
45	EDGE, JOHN H., Coalport Wire Rope and Chain Works, Shifnal, Salop	Sept. 7, 1878
46	FAIRLEY, JAMES, Craghead and Holmside Collieries, Chester-le-Street	Aug. 7, 1880
47	FARROW, JOSEPH, Brotton Mines, Brotton, R.S.O.	Feb. 11, 1882
48	FRYAR, MARK, Denby Colliery, Derby	Oct. 7, 1876
49	GERRARD, JAMES, Ince Hall Coal and Cannel Company, Wigan ...	Mar. 3, 1873
50	GREENER, HENRY, South Pontop Colliery, Annfield Plain	Dec. 11, 1882
51	GREENER, T. Y., Rainford Collieries, St. Helen's, Lancashire... ...	July 2, 1872
52	GREENER, W. J., Pemberton Colliery, Wigan	Mar. 2, 1878
53	GRESLEY, W. S., Overseale, Ashby-de-la-Zouch	Oct. 5, 1878
54	HAGGIE, PETER SINCLAIR, Gateshead-on-Tyne	April 14, 1883
55	HALLAS, G. H., Hindley Green Colliery, near Wigan	Oct. 7, 1876

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56 HAMILTON, E., Rig Wood, Saltburn-by-the-Sea ... ... Nov. 1, 1873
57 HARRIS, W. S., Andrews House, near Gateshead-on-Tyne ... ... Feb. 14, 1874
58 HEDLEY, E., Rainham Lodge, The Avenue, Beckenham, Kent ... Dec. 2, 1871
59 HENDERSON, C. W. C., Coal Owner, The Riding, Hexham ... ... Dec. 11, 1882
60 HENRY, GEO. J., Stowmarket Gun Cotton Co., Stowmarket ... ... Nov. 19, 1881
61 HILL, WILLIAM, Carterthorne Colliery Offices, Witton-le-Wear ... June 9, 1883
62 HUMBLE, STEPHEN, Uttoxeter Road, Derby ... ... Oct. 6, 1877

63 JEFFCOCK, CHARLES E., B.A., Birley Collieries, Sheffield ... ... Feb. 10, 1883
64 JEPSON, H., 54, Old Elvet, Durham ... ... July 2, 1872
65*JOBLING, THOS. E., Bebside Colliery, Cowpen Lane, Northumberland Oct. 7, 1876
66 JOHNSON, F. D., B.A., Aykleyheads, Durham ... ... Feb. 10, 1883
67 JOHNSON, W., Abram Colliery, Wigan ... ... Feb. 14, 1874
68 JORDAN, J. J., Mina de S. Domingos, Mertola, Portugal ... ... Mar. 3, 1873

69 LAVERICK, JOHN WALES, Middridge Colliery, Shildon, *via* Darlington Dec. 11, 1882
70 LIDDELL, J. M., 21, Lovaine Place, Newcastle-on-Tyne ... ... Mar. 6, 1875
71 LIDDELL, JOHN, Coal Owner, Newcastle-on-Tyne ... ... Dec. 11, 1882
72 LISLE, J., Washington Colliery, County Durham ... ... July 2, 1872

73 MACCABE, H. O., Russell Vale, Wollongong, New South Wales ... Sept. 7, 1878
74 MADDISON, THOS. R., Thornes, near Wakefield ... ... Mar. 3, 1877
75 MAKEPEACE, H. R., Calder Bank, near Airdrie... ... ... Mar. 3, 1877
76 MARKHAM, G. E., Howlish Offices, Bishop Auckland ... ... Dec. 4, 1875
77 MELLY, E. F., Griff Collieries, Nuneaton ... ... Oct. 5, 1878
78 MERIVALE, W., C.E. ... ... Mar. 5, 1881
79 MILLER, D. S., Neston Collieries, Cheshire ... ... Nov. 7, 1874
80*MILLER, N.... ... ... Oct. 5, 1878
81 MONKHOUSE, G. BENSON, St. Nicholas' Chambers, Newcastle-on-Tyne Oct. 14, 1882
82 MOORE, WILLIAM, Upleatham Mines, Upleatham, R.S.O. ... ... Nov. 19, 1881
83 MOREING, C. A., 34, Clement's Lane, London, E.C. ... ... Nov. 7, 1874
84 MORISON, JOHN, Newbattle Collieries, Dalkeith, N.B. ... ... Dec. 4, 1880

85 ORNSBY, R. E., Seaton Delaval Colliery, Dudley, Northumberland .. Mar. 6, 1875

86 PALMER, HENRY, East Howle Colliery, near Ferryhill ... ... Nov. 2, 1878
87*PEASE, ARTHUR, M.P., Coal Owner, Darlington ... ... Dec. 11, 1882
88 PHILLIPS, W. J., Ansley Hall Colliery, Atherstone ... ... June 9, 1883
89 PREST, J. J., St. Helen's Colliery, Bishop Auckland ... ... May 1, 1875
90 PRICHARD, W., Nav. and Deep Duffryn Colls., Mountain Ash, So. Wales Dec. 7, 1878
91 PRINGLE, JOS., Manager, Coxlodge Colliery, So. Gosforth, Newcastle Mar. 5, 1881
92 PROUD, JOSEPH, South Hetton Colliery Offices, Sunderland ... ... Oct. 14, 1882

93 RATHBONE, EDGAR P., 2, Great George Street, Westminster, London Mar. 7, 1874
94 RIDLEY, Sir MATTHEW WHITE, Bart., M.P., Blagdon, Northumberland Feb. 10, 1883
95 ROBSON, HARRY N., 3, North Bailey, Durham... ... ... Dec. 4, 1875
96 ROWELL, ROBERT, Seghill Colliery Office, Newcastle-on-Tyne ... Feb. 10, 1883

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97 Saise, W., D. Sc., Manager E.I.R. Collieries, Giridi, Bengal, India ... Nov. 3, 1877
98 Sawyer, A. R., Ass. R.S.M., Basford, Stoke-upon-Trent ... ... Dec. 6, 1873
99 Scurfield, Geo. J., Hurworth-upon-Tees, Darlington ... ... Dec. 11, 1882
100 Smith, J. Bagnold, Langwith Colliery, near Mansfield ... ... Nov. 2, 1878
101 Smith, Thos. Reader, M.E., Thorncliffe Collieries, near Sheffield ... Feb. 5, 1881
102 Snowball, Joseph, Seaton Burn House, Northumberland ... ... Feb. 10, 1883
103 Stobart, F., Pensher House, Fence Houses ... ... Aug. 2, 1873
104 Stobbs, Frank, 1, Queen Street, Newcastle-on-Tyne ... ... Oct. 1, 1881
105 Stones, T. H., Wigan Coal & Iron Co., Westleigh, nr. Leigh, Lancashire Nov. 7, 1874

106 Tait, James, Estate Agent, Garmondsway Moor, Coxhoe, Co. Durham May 14, 1881
107 Telford, W. H., Cramlington Colliery, Northumberland ... ... Oct. 3, 1874
108 Thomas, William, M.E., Mineral Office, The Castle, Cockermouth... Feb. 10, 1883
109 Thompson, Charles Lacy, Milton Hall, Carlisle ... ... Feb. 10, 1883
110 Turnbull, George, Seaham Colliery, Seaham Harbour ... ... Oct. 4, 1879

111 Vitanoff, Geo. N., Sofia, Bulgaria ... ... April 22, 1882

112 Walters, Hargrave, Birley Collieries, near Sheffield ... ... June 4, 1881
113 Walton, J. Coulthard, Writhlington Collieries, Radstock, *via* Bath Nov. 7, 1874
114* Ward, T. H., Assistant Manager, E.I.R. Collieries, Giridi, Bengal ... Aug. 7, 1882
115 Wardle, Edward, M.E., Radcliffe Colliery, Acklington ... ... Feb. 5, 1881
116 Watson, Robert, North Seaton, Morpeth ... ... Dec. 11, 1882
117 Webster, Ingham H., Rope Manr., Morton House, Fence Houses April 14, 1883
118 Weeks, R. L., Willington, Co. Durham ... ... June 10, 1882
119 Wilson, John R., Swaithe, near Barnsley ... ... June 9, 1883

Students.

1 Anderson, R. S., Elswick Colliery, Newcastle-on-Tyne ... ... June 9, 1883
2 Atkinson, A. A., Lumley Colliery, Fence Houses ... ... Aug. 3, 1878
3 Ayton, Henry, Seaton Delaval Colliery, Dudley, Northumberland ... Mar. 6, 1875
4 Baumgartner, W. O., East Hetton Coll. Office, Coxhoe, Co. Durham Sept. 6, 1879
5 Bell, Geo. Fred., 25, Old Elvet, Durham ... ... Sept. 6, 1879
6 Bird, Harry, Fawler Iron Mines, Charlbury ... ... April 7, 1877
7 Blackett, W. C., Jun., Sacriston, Durham ... ... Nov. 4, 1876
8 Blakeley, A. B., Hollyroyd, Dewsbury ... ... Feb. 15, 1879
9 Bramwell, Hugh, 20, Beverley Terrace, Cullercoats ... ... Oct. 4, 1879
10 Brown, C. Gilpin, Hetton Colliery, Fence Houses ... ... Nov. 4, 1876

11 Chandley, Charles, Atherton Collieries, near Manchester ... ... Nov. 6, 1880
12 Chapman, Alf. C., Silksworth Hall, near Sunderland ... ... Oct. 4, 1879
13 Child, H. ... ... Feb. 15, 1879
14 Cole, Collin, Simonside Cottage, Tyne Dock, South Shields ... Oct. 18, 1882

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15 Cox, L. Clifford, Ravenstone, near Ashby-de-la-Zouch ... ... April 1, 1876
16 Crawford, James Mill, Murton Colliery, near Sunderland ... Dec. 11, 1882
17 Crawford, T. W., Peases' West Collieries, Crook, by Darlington ... Dec. 4, 1875
18 Crone, F. E., Killingworth House, near Newcastle-on-Tyne ... ... Sept. 2, 1876
19 Curry, W. Thos., Usworth Colliery, *via* Washington, R.S.O. ... Sept. 4, 1880

20 Davidson, C. C., Ore Bank House, Bigrigg, *via* Carnforth, Cumberland Nov. 4, 1876
21 Davis, Kenneth M., Towneley and Stella Collieries, Ryton-on-Tyne April 5, 1879
22 Depledge, M. F., Eston, Middlesbrough ... ... April 7, 1877
23 Donkin, Wm. ... ... Sept. 2, 1876
24 Douglas, Arthur Stanley, Croxdale Colliery, near Durham ... June 1, 1878
25 Dunn, A. F., Poynton, Stockport, Cheshire ... ... June 2, 1877
26 Durnford, H. St. John, Low Stublin Colliery, near Rotherham ... June 2, 1877

27 Evans, David L., Messrs. Dalziel & Evans, Cardiff ... ... May 4, 1878

28 Ferens, Frederick J., 220, Gilesgate, Durham ... ... Dec. 4, 1880
29 Fletcher, John E., Ellesmere Park, Eccles, near Manchester ... Dec. 1, 1877
30 Forster, C. W., 6, Ellison Place, Newcastle-on-Tyne... ... ... June 10, 1882
31 Forster, Thomas E., Lesbury, R.S.O., Northumberland ... ... Oct. 7, 1876
32 Fowler, Robert, Wearmouth Colliery, Sunderland ... ... Dec. 2, 1876

33 Gallwey, Arthur P., El Callao Gold Mine, Guiana, Venezuela, S.A. Oct. 2, 1880
34 Gilchrist, J. R., Durham Main Colliery, Durham ... ... Feb. 3, 1877
35 Gordon, Chas., Glebe Street, Stoke-on-Trent ... ... May 5, 1877
36 Gould, Alex., Cowpen Colliery, Blyth ... ... Dec. 1, 1877
37 Green, Francis W., Harton Colliery Offices, South Shields ... April 22, 1882
38 Greig, J., Browney Colliery, Durham ... ... Feb. 5, 1881
39 Guthrie, James Kenneth, Ryton-on-Tyne ... ... Mar. 1, 1879

40 Haddock, W. T., Jun., Ryhope Colliery, Sunderland ... ... Oct. 7, 1876
41 Haggie, Douglas, Gateshead-on-Tyne ... ... April 14, 1883
42 Haig, R. Noble, Lofthouse Mines, *via* Saltburn-by-the-Sea ... Feb. 10, 1883
43 Hare, Samuel, Gladstone Street, Crook, *via* Darlington ... ... Aug. 2, 1879
44 Harrison, Robert J. ... ... May 1, 1875
45 Harrison, R. W., Public Wharf, Leicester ... ... Mar. 3, 1877
46 Hedley, Sept. H., Wardley, Newcastle-on-Tyne ... ... Feb. 15, 1879
47 Hendy, J. C. B., Middle Bitchburn Colliery, Howden-le-Wear, *via* Darlington ... ... Sept. 2, 1876
48 Heslop, Septimus, Urpeth, Chester-le-Street ... ... Dec. 4, 1880
49 Heslop, Thomas, Storey Lodge Colliery, Cockfield, *via* Darlington... Oct. 2, 1880
50 Hill, Leonard, Carlin How Mines, Carlin How in Cleveland ... Oct. 6, 1877
51 Hooper, Edward, Haydon Bridge, Northumberland ... ... June 4, 1881
52 Howard, Walter, 13, Cavendish Street, Chesterfield ... ... April 13, 1878
53 Hudson, Joseph G. S., Albion Mines, Pictou County, Nova Scotia ... Mar. 2, 1878

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54 HUMBLE, JOICEY, 17, Westmorland Terrace, Newcastle-on-Tyne ... Mar. 3, 1877
55 HUMBLE, ROBERT, 17, Westmorland Terrace, Newcastle-on-Tyne ... Sept. 2, 1876
56 HUNTER, JOHN P., Backworth Colliery, near Newcastle-on-Tyne ... Oct. 6, 1877
57 HURST, GEO., Lauder Grange, Corbridge-on-Tyne ... ... April 14, 1883

58 KAYLL, A. C., Felling Colliery, Gateshead-on-Tyne ... ... Oct. 7, 1876
59 KIRKHOUSE, E. G.... ... ... Aug. 3, 1878
60 KIRKUP, PHILIP, Esh Colliery, near Durham ... ... Mar. 2, 1878
61 KIRTON, HUGH, Waldridge Colliery, Chester-le-Street ... ... April 7, 1877

62 LINDSAY, CLARENCE S., Usworth, *via* Washington, R.S.O. ... ... Mar. 4, 1876
63 LISHMAN, ROBERT R., 33, Claypath, Durham ... ... June 9, 1883
64 LIVEING, E. H., 52, Queen Anne Street, Cavendish Square, London Sept. 1, 1877
65 LOCKE, E. G. ... ... Dec. 2, 1876
66 LONGBOTHAM, R. H., Ormskirk Road, Newton, Wigan ... ... Sept. 2, 1876

67 MACKINLAY, THOS. B., West Pelton Colliery, Chester-le-Street ... Nov. 1, 1879
68 MARSTON, FRANK, Bromfield Hall, Mold ... ... Aug. 7, 1882
69 MITTON, ARTHUR D., Sherburn House, Durham ... ... June 9, 1883
70 MURRAY, W. C., Weed Park, Dipton, *via* Lintz Green Station ... Oct. 4, 1879
71 MURTON, CHARLES J., Jesmond Villas, Newcastle-on-Tyne ... ... Mar. 6, 1880

72 NICHOLSON, JOS. C., Wear Steel and File Works, Sunderland ... Feb. 3, 1877
73 NICHOLSON, J. H., Cambois Colliery, Blyth, Northumberland ... Oct. 1, 1881
74 NOBLE, J. C., Usworth Hall, near Washington Station, Co. Durham... May 5, 1877

75 OATES, ROBERT J. W., E.I.R. Collieries, Giridi, Bengal, India ... Feb. 10, 1883

76 PATTISON, JOS. W., Londonderry Offices, Seaham Harbour ... ... Feb. 15, 1879
77 PEAKE, CHARLES EDWD., Sleaford, Lincolnshire ... ... Nov. 3, 1877
78 PEAKE, R. C., Highgate, Wallsall ... ... Feb. 7, 1880
79 PEART, A. W., Lower Duffryn Collieries, near Mountain Ash ... Nov. 4, 1876
80 PEASE, J. T., Loftus Mines, Cleveland ... ... June 9, 1883
81 PIKE, ARNOLD, Kimblesworth Colliery, Chester-le-Street ... ... Feb. 5, 1881
82 POTTER, E. A., Cramlington House, Northumberland ... ... Feb. 6, 1875
83 PRICE, S. R., Houghton Main Colliery, near Barnsley, Yorkshire ... Nov. 3, 1877
84 PRINGLE, H. A., Peases' West Collieries, by Darlington ... ... Oct. 2, 1880
85 PRINGLE, HY. GEO., Tanfield Lea Coll., Lintz Green Station, Newcastle Dec. 4, 1880
86 PROCTOR, C. P., Shibden Hall Collieries, near Halifax, Yorkshire ... Oct. 7, 1876

87 REED, R., North Seaton Colliery, Morpeth ... ... Feb. 3, 1877
88 RICHARDSON, RALPH, Field House, West Rainton, Fence Houses ... June 9, 1883
89 RICHARDSON, R. W. P., Office of General Manager, Cedral Mining and Smelting Co.'s Mines, Villa de Musquiz Coalmila, Mexico ... Mar. 4, 1876
90 RIDLEY, WILLIAM, South Tanfield Colliery, Chester-le-Street ... Dec. 11, 1882

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ELECTED.

91 ROBINSON, FRANK, Norley Colliery, Wigan ... ... Sept. 2, 1876
92 ROBINSON, GEO., Hebburn Colliery, near Newcastle-on-Tyne ... ... Nov. 4, 1876
93 ROBSON, THOS. O., Medomsley, Newcastle-on-Tyne ... ... Sept. 11, 1875
94 ROUTLEDGE, W. H., Staveley Coal and Iron Co. Limited, Chesterfield Oct. 7, 1876

95 SCARTH, R. W., Stanghow House, Stanghow, *via* Marske-by-the-Sea Dec. 4, 1875
96 SCOTT, JOSEPH SAMUEL, East Hetton Colliery, Coxhoe, Co. Durham Nov. 19, 1881
97 SCOTT, WALTER, Cornsay Colliery, Lanchester, Co. Durham ... ... Sept. 6, 1879
98 SCOTT, WM., Brandon Colliery Offices, near Durham ... ... Mar. 4, 1876
99 SMITH, THOS., Leadgate, Co. Durham ... ... Feb. 15, 1879
100 SMITH, T. F., Jun., Cinderford Villas, near Newnham, Gloucestershire May 5, 1877
101 SOUTHERN, E. O., Breeze Hill, Whitehaven ... ... Dec. 5, 1874
102 SOUTHERN, THOMAS, Cwmaman Colliery, near Aberdare, South Wales Dec. 17, 1881
103 SPENCE, R. F., Cramlington ... ... Nov. 2, 1878
104 STEAVENSON, C. H., Durham ... ... April 14, 1883
105 STOBART, HENRY TEMPLE, Eton Villa, Saltburn-by-the-Sea ... ... Oct. 2, 1880
106 STOKER, ARTHUR P., Birtley, near Chester-le-Street ... ... Oct. 6, 1877

107 TODD, JOHN T., Hetton-le-Hole, Fence Houses ... ... Nov. 4, 1876
108 TODNER, W. J. S., 33, Beaumont Street, Elswick, Newcastle-on-Tyne Sept. 6, 1879
109 TOPHAM, EDWARD C., Marsden, South Shields ... ... Nov. 3, 1877

110 WAUGH, CHARLES L., The Burroughes, Cockermouth, Cumberland ... Nov. 19, 1881
111 WHITE, C. E., Hebburn Colliery, near Newcastle-on-Tyne ... ... Nov. 4, 1876
112 WILSON, J. D., Ouston House, Chester-le-Street ... ... Sept. 11, 1875

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Subscribers under Bye-law 9.

1 Ashington Colliery, Newcastle-on-Tyne.
2 Birtley Iron Company, Birtley.
3 Haswell Colliery, Fence Houses.
4 Hetton Collieries, Fence Houses.
5 Lambton Collieries, Fence Houses.
6 Londonderry Collieries, Seaham Harbour.
7 Marquess of Bute.
8 North Hetton Colliery, Fence Houses.
9 Ryhope Colliery, near Sunderland.
10 Seghill Colliery, Northumberland.
11 South Hetton and Murton Collieries.
12 Stella Colliery, Hedgefield, Blaydon-on-Tyne.
13 Throckley Colliery, Newcastle-on-Tyne.
14 Victoria Garesfield, Lintz Green.
15 Wearmouth Colliery, Sunderland.

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CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased); THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased); SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments

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and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. AND WHEREAS in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said LINDSAY WOOD, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. NOW KNOW YE that we, being desirous of encouraging a design so laudable and salutary of our special grace, certain knowledge, and mere motion, have willed granted, and declared, and

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do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes and mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectfully at the rack rent which might have been had or gotten for the same respectfully at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial licence and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule

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and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectfully shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held, and for convening the same and regulating the proceedings thereat, and

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for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, this 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

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THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A GENERAL MEETING ON THE 16TH JUNE, 1877.

1.—The members of the North of England Institute of Mining and Mechanical Engineers shall consist of four classes, viz.:—Original Members, Ordinary Members, Associate Members, and Honorary Members, with a class of Students attached.

2.—ORIGINAL MEMBERS shall be those who were Ordinary Members on the 1st of August, 1877.

3.—ORDINARY MEMBERS.—Every candidate for admission into the class of Ordinary Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-eight years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other recognised branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least five years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have practised on his own account in the profession of an Engineer for at least five years, and have acquired a considerable degree of eminence in the same.

4.—ASSOCIATE MEMBERS shall be persons practising as Mining or Mechanical Engineers, or in some other recognised branch of Engineering, and other persons connected with or interested in Mining or Engineering.

5.—HONORARY MEMBERS shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or some other of the recognised branches of Engineering, and such persons may continue Students until they attain the age of twenty-three years.

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7.—The annual subscription of each Original Member, and of each Ordinary Member who was a Student on the 1st of August, 1877, shall be £2 2s., of each Ordinary Member (except as last mentioned) £3 3s., of each Associate Member £2 2s., and of each Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

8.—Any Member may, at any time, compound for all future subscriptions by a payment of £25, where the annual subscription is £3 3s., and by a payment of £20 where the annual subscription is £2 2s. All persons so compounding shall be Original, Ordinary, or Associate Members for life, as the case may be; but any Associate Member for life who may afterwards desire to become an Ordinary Member for life, may do so, after being elected in the manner described in Bye-law 13, and on payment of the further sum of £5.

9.—Owners of Collieries, Engineers, Manufacturers, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten persons; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10.—In case any Member, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 8, and may thereupon constitute him a Life Member, or permit him to resume his former rank in the Institute.

11.—Persons desirous of becoming Ordinary Members shall be proposed and recommended, according to the Form A in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must be signed by the proposer and at least five other Members certifying a personal knowledge of the candidate. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who on approving the qualifications shall determine if the candidate is to be presented for ballot, and if it is so deter-

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mined, the Chairman of the Council shall sign such approbation. The same shall be read at the next Ordinary General Meeting, and afterwards be placed in some conspicuous situation until the following Ordinary General Meeting, when the candidate shall be balloted for.

12.—Persons desirous of being admitted into the Institute as Associate Members, or Students, shall be proposed by three Members; Honorary Members shall be proposed by at least five Members, and shall in addition be recommended by the Council, who shall also have the power of defining the time during which, and the circumstances under which, they shall be Honorary Members. The nomination shall be in writing, and signed by the proposers (according to the Form B in the Appendix), and shall be submitted to the first Ordinary General Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next Ordinary General Meeting, when the candidate shall be balloted for.

13.—Associate Members or Students, desirous of becoming Ordinary Members, shall be proposed and recommended according to the Form C in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must certify a personal knowledge of the candidate, and be signed by the proposer and at least two other Members, and the proposal shall then be treated in the manner described in Bye-law 11. Students may become Associate Members at any time after attaining the age of twenty-three on payment of an Associate Member's subscription.

14.—The balloting shall be conducted in the following manner:—Each Member attending the Meeting at which a ballot is to take place shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form D in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members voting.

15.—Notice of election shall be sent to every person within one week after his election, according to the Form E in the Appendix, enclosing at the same time a copy of Form F, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise should become void.

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16.—Every Ordinary Member elected having signed a declaration in the Form F, and having likewise made the proper payment, shall receive certificate of his election.

17.—Any person whose subscription is two years in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form G in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter, according to the Form H in the Appendix, of declaring that the defaulter has ceased to be a member.

18.—In case the expulsion of any person shall be judged expedient by ten or more Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half the Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form I in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the persons present at such Meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that Meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form J in the Appendix.

19.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Original, Ordinary and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past

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year; but such Members shall be eligible for re-election after being one year out of office.

20.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

21.—Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The Votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant offices, and a new Officer or Officers shall be elected at the succeeding Ordinary General Meeting.

23.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

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24.—In the absence of the President, it shall be the duty of senior Vice-President present to preside at the meetings of the Insti to keep order, and to regulate the proceedings. In case of the abs of the President and of all the Vice-Presidents, the meeting may any Member of Council, or in case of their absence, any Member pre to take the chair at the meeting.

25.—The Council may appoint Committees for the purpose of tran ing any particular business, or of investigating specific subjects conn with the objects of the Institute. Such Committees shall report t Council, who shall act thereon as they see occasion.

26.—The Treasurer and the Secretary shall act under the dire and control of the Council, by which body their duties shall from tin time be defined.

27.—The Funds of the Society shall be deposited in the hands Treasurer, and shall be disbursed or invested by him according t direction of the Council.

28.—The Copyright of all papers communicated to, and accept printing by the Council, and printed within twelve months, shall b vested in the Institute, and such communications shall not be pub for sale or otherwise, without the written permission of the Council.

29.—An Ordinary General Meeting shall be held on the first Sat of every month (except January and July) at two o'clock, unless oth determined by the Council; and the Ordinary General Meeting month of August shall be the Annual Meeting, at which a report proceedings, and an abstract of the accounts of the previous year be presented by the Council. A Special General Meeting shall be whenever the Council may think fit, and also on a requisition Council, signed by ten or more Members. The business of a S Meeting shall be confined to that specified in the notice convening

30.—At meetings of the Council, five shall be a quorum. minutes of the Council's proceedings shall be at all times open inspection of the Members.

31.—All Past-Presidents shall be *ex-officio* Members of the Cou long as they continue Members of the Institute, and Vice-President have not been re-elected or have become ineligible from having hel for three consecutive years, shall be *ex-officio* Members of the Cou the following year.

32.—Every question, not otherwise provided for, which shal before any Meeting, shall be decided by the votes of the majority Original, Ordinary, and Associate Members then present.

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33.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

34.—All proofs of reports of discussions, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

35.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

36.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use.

37.—Members elected at any meeting between the Annual Meetings shall be entitled to all papers issued in that year, so soon as they have signed and returned Form F, and paid their subscriptions.

38.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

39.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members unless by written order from the Council.

40.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote. Any Member of the Institute shall also have power to introduce two strangers (see Form L) to any General Meeting, but they shall not take part in the proceedings except by permission of the Meeting.

41.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved,
R. ASSHETON CROSS.

Whitehall,
2nd July, 1877.

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APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-eight years of age, and desirous of being elected an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him from *personal knowledge* as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed_____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____
_____
_____ } Five Members.
_____
_____

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a of the North of England Institute of Mining and Mechanical Engineers.

Signed_____ Chairman.

Dated this day of 18

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[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become [an Honorary Member, or an Associate Member, or a Student] thereof.

_____
_____
_____ } Three* Members.
_____
_____

* If an Honorary Member, five signatures are necessary, and the following Form must be filled in by the Council.

Dated this day of 18

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-eight years of age, and being desirous of becoming an Ordinary Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the Qualifications of the Candidate according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed _____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being

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convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____ } Two
_____ } Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM D.]

List of the names of persons to be balloted for at the Meeting on , the day of 18

ORDINARY MEMBERS:—

_____

_____

_____

ASSOCIATE MEMBERS:—

_____

_____

HONORARY MEMBERS:—

_____

_____

STUDENTS:—

_____

_____

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM E.]

SIR,—I beg leave to inform you that on the day of you were elected a of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me

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with your signature, and until your first annual subscription be paid, the amount of which is £ , or, at your option, the life-composition of £

If the subscription is not received within two months from the present date, the election will become void under Bye-law 15.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM F.]

I, the undersigned, being elected a of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this day of 18

[FORM G.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 17, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid. and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, Sir,

Yours faithfully,

Secretary

Dated 18

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ASSOCIATE MEMBERS—

Mr. CHARLES DAVISON, Cornsay Colliery, near Esh, Durham.
Mr. JOHN WALES LAVERICK, Middridge Colliery, Shildon, *via* Darlington.
Mr. FREDERICK BERKLEY, M.E., Murton Colliery, near Sunderland.
Mr. JOHN LIDDELL, Coal Owner, Newcastle-on-Tyne.
Mr. THOMAS HUGH BELL, Coal Owner, Middlesbrough-on-Tees.
Mr. HENRY GREENER, South Pontop Colliery, Annfield Plain.
Mr. C. W. C. HENDERSON, Coal Owner, The Riding, Hexham.
Mr. C. J. BATES, Coal Owner, Heddon Banks, near Wylam.
Mr. ARTHUR PEASE, M.P., Coal Owner, Darlington.
Mr. ROBERT WATSON, North Seaton, Morpeth.
Mr. GEO. J. SCURFIELD, Hurworth-upon-Tees, Darlington.

STUDENTS—

Mr. WILLIAM RIDLEY, South Tanfield Colliery, Chester-le-Street.
Mr. JAMES MILL CRAWFORD, Murton Colliery, near Sunderland.

Mr. CHARLES TYLDEN-WRIGHT, F.G.S., then read the following paper on "The Channel Tunnel:"—

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THE CHANNEL TUNNEL.

By CHARLES TYLDEN-WRIGHT, F.G.S.

This subject, which has excited so much interest from an engineering as well as a political and commercial point of view, has already been discussed at the meetings of the British Association and before numerous scientific societies; but the questions and difficulties connected with it fall so much more within the province of the mining than of any other profession, that the discussion which should follow the reading of this paper will go far to prove whether the scheme is as feasible as its promoters believe it to be, or as hopeless as it was considered five years since. Having had special facilities for visiting the experimental works at Dover and Sangatte, the writer now lays before the Institute some drawings and notes on the subject.

It may conveniently be divided into five sections:—

1.—General description.
2.—Geological formation through which it will be carried.
3.—Machinery for driving the tunnel.
4.—Temporary and permanent haulage.
5.—Temporary and permanent ventilation.

1.—GENERAL DESCRIPTION.

It is proposed to carry the tunnel, or tunnels, entirely in the grey chalk, at a depth of not less than 150 feet below the sea bottom.

For a distance of two miles on each side it will descend at a gradient of 1 in 80, and then rise to the centre of the Channel at a gradient of 1 in 2,000; so that any water that may be cut will run back within two miles of the shore; and pumping engines, worked by compressed air, will either be fixed there, or a water level carried to land and pumps fixed over it. This arrangement would provide one of the numerous methods of closing the tunnel at any time without permanently injuring it.

It is an open question whether it is desirable to drive a single tunnel of, say 24 feet diameter, for two lines of rails, or two tunnels of 14 feet each, but the arguments appear to be in favour of two tunnels, for the following reasons:—

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1.—Greater safety; it being impossible for any single accident to affect both lines.

2.—Reduced risk of disturbing the strata in the smaller tunnel.

3.—Improved ventilation: the air travelling with, but at a less velocity than, the trains.

2.—GEOLOGICAL FORMATION.

Among the numerous papers which have been read on the geology of the district, the most complete seems to be that by Professor Boyd Dawkins, before the Manchester Geological Society, and the writer is indebted to that gentleman and to Mr. Brady, the engineer of the Submarine Railway Company, for the geological maps and sections accompanying this paper.

Plate I. represents the English coast line, showing the different strata cut in passing from Folkestone to Dover. The lowest bed is the gault clay *a*, an impervious stratum, of which the following is an analysis:—

Carbonate of lime	20 %
Oxide of iron	15
Alumina	12
Silica	46
Water	7
	100

This is at least 200 feet thick. Above this is a thin and irregular bed of chalk marl *b*, called the Upper Green Sand, the greatest thickness observed being 15 feet.

Next is the grey chalk *c*, 225 feet thick, and it is in this bed that it is proposed to carry the tunnel. It contains:—

Carbonate of lime	70·00 %
Silica	16·00
Alumina	5·00
Oxide of iron	2·50
Magnesia	2·50
Water	4·00
	100·00

The silica especially predominates in the lower beds, which are of a darker colour than the upper.

On the English side it is dry, except at joints; and, though more than 2,800 yards have been driven, chiefly below high water mark, no pumps have been required, and the chalk is strong enough to stand in the headings 7 feet diameter, entirely without timber.

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The next bed is the white chalk, without flints, *d*; this is much more porous, and about 145 feet thick. Then comes the upper chalk containing flints, about 480 feet thick. This formation is very heavily watered, and from it London and the south east of England derive most of their spring water.

The dip is very slight, about 1 in 70 to the north, so that the strata lie very favourably for the tunnel to be carried under the Channel on the line of strike.

There is very little evidence of faults on the English side, the largest observed being one of 25 feet; but the French section, Plate IV., shows the ground to be very much disturbed by them, and the French engineers have consequently had much heavier feeders of water to contend against, both in their shaft and in their heading.

The works already executed on the English side consist of a shallow shaft at Abbot's Cliff; 800 yards of heading connected with the shore by a horizontal gallery above the sea level; No. 2 shaft at the east end of the Shakespeare tunnel, 163 feet deep, cased with boards; and a heading, about 2,000 yards long, 7 feet diameter.

Thus about one-tenth of the distance that would be driven in the same stratum to the centre of the Channel has been completed without encountering the smallest difficulty—a strong augury of success.

Plate II. is a geological map of the Channel and of the coast on each side. What is known of the sea bottom of the Channel itself is derived from the very complete and careful investigations of the French Commission appointed by l'Association de Chemin de Fer Sous-marin entre la France et l'Angleterre.

More than 7,000 soundings were taken, and about 3,250 specimens of the sea bottom were obtained. The line A B on the map, divided into miles, shows the proposed line of tunnel, by which it would be carried the whole distance through the grey chalk, with, in places, a very slight covering of the upper chalk without flints.

Plate III. is the probable section across the Channel on the line of the tunnel. The greatest observed depth of water is 210 feet.

Plate IV. is a section along the French coast from Calais to Ste. Pol.

The ground appears to be more faulty than on the English side, and there is a considerable twist in the dip of the strata, but the continuity and uniformity in section on the two sides of the Channel are very remarkable. The grey chalk is 226 feet thick on the English and 223 feet on the French side. It appears very probable therefore that, when the French heading has been carried into the chalk with the normal dip, it will be as free of joints and slips as on the English side.

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The shaft at Sangatte is 18 feet diameter and 226 feet deep. The heavy feeders of water have been stopped back by wood tubbing of twenty-four sides, and a direct-acting pumping engine working an 18-inch lift with 9 feet stroke has been erected, but at Easter it was only making one stroke per minute.*

Two tunnels are commenced, each 7 feet diameter and 6 yards apart, almost in a vertical line, the lower for drainage.

3.—BORING MACHINE.

There can be no doubt but that the success of the experimental heading, and the sudden change in public opinion in the last year as regards the feasibility of the enterprise, are due to the use of compressed air as the motive power, and the employment of a machine so exactly suited to the material as the boring machine of Colonel Beaumont, R.E., and Captain English, R.E.

It consists of a borehead *a*, having a radius of 3 feet 6 inches, and carrying seven cutters on each arm. Plate V. The machine that has been working on the English side is driven at the rate of $2\frac{1}{2}$ revolutions per minute by a pair of engines, 12-inch cylinders and 10-inch stroke, running at 125 revolutions per minute.

The whole machine is about 33 feet long, and its action when at work is as follows:—

The upper bed *b*, carrying the whole of the machinery, including the chain of buckets, is moved, by a screw feed, gradually forward on the lower bed *c*, which is fixed to and rests on the bottom of the tunnel.

The feed is from $\frac{2}{16}$ to $\frac{3}{4}$ inch per revolution, and the borehead can work up to four revolutions per minute. When the cut is done, that is, after the upper bed has slid over the lower, a distance of 4 feet 4 inches, hydraulic jacks lift the upper bed and machine, carrying with it the lower bed, which is thus lifted clear of the floor. The advancing gear is then reversed, and the lower bed made to slide under the upper, after which the jacks are lowered, and the machine is in position to recommence operations, the stoppage involved not exceeding five minutes.

Only two men are in attendance on the machine, one at the borehead to shovel the *débris* from the bottom of the heading into the buckets *d* attached to the endless strap, which deliver it into tubs at the tail of the machine; the other to drive the machine. Two more men are required to change the tubs and put on fresh air pipes.

* Since this was written a second and more powerful pumping engine has been erected, and is now at work.

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From the above it will be seen that the tunnel, under present conditions, can easily be driven at the rate of 40 yards per day at each end. Thus a 50-inch cut can be made in 25 minutes (four revolutions per minute with ½-inch feed); 15 minutes is ample for shifting the bed plate forward, oiling the machine, and putting in new cutters when required, the various operations going on simultaneously. This would give an advance of 4 feet in 40 minutes, 6 feet per hour, or 48 yards in 24 hours.

The engines on the French side, where a newer and more powerful machine of Colonel Beaumont's is in operation, have 12-inch cylinders and 18-inch stroke.

As stated above, the trial heading requires no timber, and what little water has been met with has been stopped back by metal tubbing rings bolted together; but the permanent tunnel will no doubt require lining, and most suitable material for making into hydraulic cement is at hand in the grey chalk, and the flint pebbles on the beach, the two making a strong and durable concrete.

HAULAGE.

The questions of transporting the *débris* during construction and the subsequent working of the tunnel are intimately connected and may be conveniently treated together; in both cases it may be assumed that the steam and noxious fumes of the ordinary locomotive are inadmissible. Where the traffic is almost continuous, as it would be in the cases under consideration, and every engine consumed about 800 lbs. of coal or coke in passing through the tunnel, an enormous and perfectly impracticable ventilation would be required so to dilute the products of combustion as to make the tunnel bearable. Mr. Morrison, in his paper on "The Ventilation and Working of Tunnels,"* estimates that ventilating machinery of 4,000 horse-power would be necessary for forty trains per day, while Mr. D. K. Clark shows by calculation that 15,000 horse-power would be required for only four trains per day; so that a very moderate estimate would be engines and fans of 2,000 horse-power at each end.

Traction by endless ropes is quite feasible, as evidenced by what is done in collieries where 100 tons per hour are frequently drawn along engine roads from 2,000 to 3,000 yards long.

Assuming the 7 feet headings on each side to advance at the rate of 30 yards per day, the *débris* from each end would amount to about 232 tons per 24 hours, or 9·6 tons per hour, and in the enlarged 14 feet tunnel, supposing 18 feet in diameter to be excavated, there would be

* Proceedings of the Institute of Civil Engineers, Vol. XLIV., 1876.

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about 1,300 tons per 24 hours, or 54 tons per hour, to be removed, in addition to the material taken in-bye for lining and other purposes.

The endless rope system would, however, here work under very great disadvantage, as the position of the working face would advance so rapidly, and necessitate the removal of the puller by-bye about twice a week.

For the permanent working of railways all systems of rope haulage have invariably given place to the locomotive; indeed, the advantages of carrying the power with the train in this case, leaving the roadway clear for lining operations, are so obvious that it is not necessary to emphasize them.

It would probably be difficult, if not impossible, to work endless or any system of rope haulage in greater lengths than three miles (*i.e.* six miles of rope), so that there would be three stations and shunts during construction, and six in the permanent tunnel.

It remains then to consider what, if any, improvement upon this the substitute of compressed air would make.

As now constructed the air locomotive possesses the same power and will do precisely the same character of work as the steam locomotive. It can be replenished with air more quickly than a tender with water, and it can run comparatively long distances with a single charge of air.

Instead of vitiating the air the working of the engine helps to purify it, and, as will be shown subsequently, a sufficient amount of pure air will, under ordinary circumstances, be given off to render any other ventilation unnecessary.

Compressed air locomotives would therefore appear to be at present the best known and most suitable power for working tunnels of such length, and a small one, constructed on Colonel Beaumont's system, is now at Dover ready to remove the *débris* when work is resumed.

Its leading dimensions are as follows:—

High pressure cylinders	2 inches diameter.
Low „ „	7 „ „
Stroke	12 „ „
Leading and driving wheels...	24 „ „
Trailing wheels	14 „ „
Weight of engine and receiver	153 cwts.
Cubic contents of receiver	65 feet.
Gauge of road	22½ inches.

There is nothing new in the use of compressed air for locomotive purposes, but what *is* novel is the means by which a comparatively small volume of air is now made to do practical work.

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This is brought about by :—

1.—A proper recognition of the part which heat plays in such machines.

2.—The possibility of now using pressures which the early users of this power have not attempted.

3.—Taking advantage of the expansion from these high pressures, thus avoiding the loss involved by reducing valves.

Thus, in the engine here illustrated the air is admitted into the 2-inch cylinders at a maximum pressure of 1,000 lbs. per square inch; after being warmed by steam generated by a slow combustion stove under the foot-plate, it is carried thence into the 7-inch cylinders, these as well as the 2-inch cylinders being steam-jacketed. It is estimated that this engine will run five miles with a gross load of 8 tons without re-charging the receiver.

The merits of any system of compressed air locomotion must depend on the amount of power that can be stored and the proportion of such stored energy that can be rendered available.

The engines of Messrs. Lishman and Young which have, the writer believes, been working satisfactorily for some years at Lord Durham's collieries and elsewhere, work at comparatively low pressures, say 350 lbs. per square inch; the working gear is of the ordinary locomotive pattern, and no attempt is made to heat the air. An ordinary stop-cock provides the means for reducing the air from the receiver pressure to the low pressure used in the working cylinder.

The Grange Iron Company, the makers of these engines, state that a receiver of 70 cubic feet capacity would draw a load of 25 tons one mile without re-charging; but, according to the figures given above of the engine now at the tunnel, a receiver of this capacity would move 70 tons one mile. It therefore appears that the Beaumont engine would be very much more suitable for the haulage of the *débris* of the Channel Tunnel.

The Mackarski system, now working the tramways at Nantes, in France, works at about the same pressure as Messrs. Lishman and Young's engines, but a special form of reducing valve is used, and the air, after passing the reducing valve, is warmed by being passed through water highly heated; it thus becomes mixed with steam, and the engine works with increased efficiency.

But Colonel Beaumont's appears to be the only system that admits the air direct into the cylinders at the reservoir pressure of 1,000 lbs. per square inch, and provides the heat necessary for isothermal expansion by steam-jacketing; the loss from the use of a reducing valve is avoided, and

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there is no consumption of steam, the steam being used only as a convenient means of conveying heat to the compressed air, after which it is returned as hot water to the small boiler on the engine.

This system has been successfully employed in New York, on the New Metropolitan Tramways near London, and in the Victoria Docks; and Mr. Carr, the Company's engineer, has published the following results :—

Jan. 27th.—Air compressed locomotive made for tramway rail, weight about 7 tons, working on a straight level line in the Royal Albert Dock, back of No. 35 shed, 100 yards in length, drawing an open truck weighing 5 tons, loaded with 11¼ tons of brick rubbish.

Total weight moved, including engine, 23½ tons; pressure in receiver at starting, 925 lbs.

Air Pressure. Lbs.			Minutes.			Lbs.
405	925	ran 1,000 yards in	9	reduced pressure to		805
	805	„ „	9	„	„	730
	730	„ „	9	„	„	660
	660	„ „	13	„	„	595
	595	„ „	10	„	„	520

5,000 yards run—loss, 405 lbs., in 50 minutes; 3 miles 73 yards per hour.

Air Pressure. Lbs.			Minutes.			Lbs.
	520	ran 1,000 yards in	10	reduced pressure to		435
	435	„ „	10	„	„	360
	360	„ „	10	„	„	288
	288	„ „	10	„	„	205

4,000 yards run—loss 315 lbs.

Thus a gross load of 23½ tons was taken a distance of nearly 5¼ miles with a diminution of 720 lbs. from an initial pressure of 925 lbs. per square inch, in a reservoir having a capacity of 60 cubic feet. This is equivalent to an expenditure of 42 cubic feet of air at 1,000 lbs. initial pressure, which represents, for the work above-mentioned, *a duty of say 3 tons, conveyed one mile for each cubic foot of air consumed.*

For the *permanent traffic* of the tunnel the use of compressed air is even more necessary than for the removal of the *débris*.

Plate VI. is a drawing of such an engine proposed by Col. Beaumont; its leading dimensions being :—

Cylinders, high pressure	6½ inches diameter.
„ low „	22 „ „
Stroke	36 „
Driving wheels	10 feet „

This would admit of an air receiver 4 feet diameter below the axles, with a cubic capacity of 350 feet, another above the axles, and two of the same size on the tender, giving a total capacity of 1,400 cubic feet, which would be sufficient to carry a train of 150 tons gross a distance of 20 miles at 30 miles per hour.

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Provision would, however, be made by means of a high-pressure main, connected with the receivers at intervals of 4 or 5 miles, to take in fresh charges.

An ordinary locomotive consumes about 35 lbs. per train mile, or 7·5 cwts. for 24 miles, and the experiments made by Messrs. Greathead and Eykyn in January last, referred to in the following report of Captain D. Galton, show that the amount of coal required to haul one ton one mile by compressed air engines, working at an initial pressure of 1,000 lbs. per square inch, is 0·2928 lbs., or about 9·6 cwts. for 150-ton train running through the tunnel.

SUMMARY OF TRIALS MADE WITH THE BEAUMONT COMPRESSED-AIR LOCOMOTIVE AT THE NORTH METROPOLITAN COMPANY'S DEPÔT, STRATFORD, JANUARY 24TH, 25TH, 26TH, AND 27TH, 1882, BASED ON DETAILED REPORT OF MESSRS. GREATHEAD, C.E., & EYKYN, C.E., REFERRED TO IN REPORT OF CAPTAIN DOUGLAS GALTON, F.R.S., RICHARD PRICE WILLIAMS, C.E., AND WILLIAM KIRTLEY, LOCOMOTIVE SUPERINTENDENT, LONDON, CHATHAM, AND DOVER RAILWAY.

AIR-COMPRESSOR.—The boiler of the Air-Compressing Engine was a locomotive boiler of the ordinary type.

For compressing the air, a compound high-pressure horizontal engine with variable cut-off was used, having two cylinders of 12 in. and 20 in. diameter and 2 ft. stroke with cranks set opposite, and working directly four stage pumps of 12 in., 6½ in., 4 in., and 2½ in., diameter respectively, placed in two tanks of water. Intermediate coils between the pumps served to cool the air, so that it was barely warm on leaving the compressor.

The air, cold, after passing through a considerable length of small iron pipes, was delivered direct into the reservoir of the locomotive.

LOCOMOTIVES.—Consisted of a pair of engines working on four cranks set in two opposite pairs, each pair of opposite cranks being at right angles to the other, each high and low-pressure cylinder being connected to each pair of opposite cranks.

Diameter of the cylinders, high-pressure 2 in., low-pressure 7 in., stroke 18 in. Variable cut-off, from 0 to full. Driving done by the cut-off.

The air was heated before entering the cylinders by being passed through steam-jacketed coils, the steam being supplied from a small boiler on the locomotive.

The air-cylinders were also steam-jacketed. The driving-wheels were 3 ft. in diameter. The capacity of the reservoir was 96·2 cubic feet.

NOTE.—The feed-water to boiler was supplied quite cold by a small donkey-engine.

The firing was done by hand, and the state of the fire was carefully observed, so as to secure at the termination of each trial as nearly as possible the same fire as at the commencement.

The quantity of coal used for getting up steam was 6 cwt., the boiler full of water to begin with being too hot for the hand, but with no pressure.

The height of water in the boiler was also noted; on January 24th (trial No. 1) it was the same at the finish as the start, but on January 25th (trial No. 2) the level was ½ in. lower at the finish than at the start.

The steam-pressure was also noted from time to time, and at the commencement and ending of each trial it varied between 95 lbs. and 100 lbs. per square inch.

The power given by the locomotive was measured by a friction dynameter, the engine being lifted so that its driving-wheel ran freely.

Counters were fixed both on the locomotive and compressing engine.

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TRIALS.

JANUARY 24TH AND 25TH.

To determine the quantity of fuel consumed, indicated horse-power of compressing engines, and corresponding power given off by the locomotive, the pressure of air in the locomotive being maintained constant at 1,000 lbs. and 750 lbs. per square inch.

	1,000 lbs.	750 lbs.
Duration of trial	H. M. 4 0	H. M. 4 0
Fuel consumed { Under main boiler	cwts. lbs. 10 56	cwts. lbs. 10 0
Fuel consumed { To heat expanding air in the locomotive	52	44
INDICATED POWER OF COMPRESSING ENGINES—		
Total number of revolutions	11,473	12,052
Average per minute	47·8	50·21
H.P. developed by high-pressure cylinder... ...	36·37	39·11
H.P. developed by low-pressure cylinder	28·92	30·97
Total power exerted by engines	65·29	70·08
Actual consumption of coal per indicated horse-power per hour	4·5 lbs.	4·0 lbs.
HORSE-POWER DEVELOPED ON THE BRAKE BY THE LOCOMOTIVES—		
Total number of revolutions	17,755	18,974
Average number of revolutions per minute ...	73·98	79·0
Mean power exerted, H.P.	13·12	14·0
Percentage of the indicated horse-power of the compressing engines	20·1	20·0

JANUARY 26TH.

To determine the quantity of effective power stored in the reservoir of the locomotive as given off on the brake, capacity of reservoir being 96·2 cubic feet, the power exerted by the engine was practically kept constant throughout the trial.

	First Experiment.	Second Experiment.
Initial pressure in reservoir	1,000 lbs.	1,000 lbs.
Final pressure in reservoir, the engine being stopped by the brake	260	275
Duration of run	39 minutes	37 minutes
Total number of revolutions	3,403	3,113
Average per minute	87·25	84·17
Units of foot-pounds of work given off on the brake ...	12,731,439 lbs.	11,646,480 lbs.
Mean power	9·88 H.P.	9·53 H.P.
Units of H.P. for one minute per cubic foot of air consumed from 1,000 lbs.	5·36 H.P.	5·06 H.P.
Amount of coal actually consumed per cubic foot of air at 1,000, engine consuming an average of 4·2 lbs. of coal per H.P. per hour	1·8 lbs.	1·8 lbs.
Amount of coal which would be used with economical engines working at 2 lbs. per H.P. per hour, to put 1 cubic foot of air up to 1,000	0·87 lbs.	0·87 lbs.
Amount of coal required to haul one ton one mile on a railway	0·2928 lbs.	
Amount of coal required to haul one ton one mile on a tramway	0·73 lbs.	

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The engines of "The Invicta," now running between Dover and Calais, indicate 4,000 horse-power while crossing the Channel, and compressing engines of the same power, assuming only 20 per cent. of the power to be realised in the locomotives, would be sufficient to keep three trains each way constantly in motion, that is, a train each way every twenty minutes.

Obviously, if such a result can be obtained, there will be no difficulty in working the tunnel when made.

The writer does not propose to enter into the general question of cost, but it will readily be seen that if the rate of progress which has already been attained at both ends of the tunnel can be maintained, say 60 yards per day, the trial heading will be completed within two years by a very limited number of workmen; and that if, as will no doubt be the case, the permanent tunnel is carried on at the same time, one line might be open for traffic within three years. The cost, therefore, of the boring will be exceedingly small for the work to be done, and it has already been shown that the lining by means of concrete, of which the principal component is brought out of the tunnel as *débris*, must be much below the ordinary cost of such work.

The haulage, however, has been considered by some engineers a matter of such difficulty that extraordinary suggestions have been made for dealing with it. Among others Mr. Crampton* proposes to mix the chalk as excavated with either four or thirteen times its weight of water, which is to be conveyed to the face, an ultimate distance of eleven miles, in pipes; the water and chalk are then to be converted into slime in an agitator and piped back to the shaft and pumped to the surface.

Even supposing there was no objection to carrying water where it is not wanted, or to lifting four or thirteen times the weight necessary, the writer would ask what would be the effect of a momentary stoppage of the flow in pipes charged with slime, running at so flat a gradient as 1 in 2,000, or forced up an ascending gradient of 1 in 80? The pipes would be liable to be choked by solid cores in many places which there would be the greatest difficulty in finding.

The ordinary form of haulage either by ropes or compressed-air locomotives can, no doubt be satisfactorily applied, and will not exceed the maximum cost of 4d. per ton for underground mechanical haulage, given in the admirable Report on Underground Haulage of the Tail Rope Committee appointed by the Institute, published in 1867–8. It will probably be less, but on that basis, assuming chalk to weigh 150 lbs. per

* Paper read before the Mechanical Engineers at Leeds, 1882.

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cubic foot, the length of the tunnel to be 22 miles, and the *débris* to have an average lead of 5½ miles, the haulage of the refuse from the

7-foot tunnel would cost	£27,500
and from the permanent tunnel	154,000
Total	£181,500

VENTILATION.

If compressed air has to be the motive power both for the boring machine and haulage engines, and if no horses be employed underground, the heading being lighted, as hitherto, by incandescent electric light, the question of ventilation, which has been considered such a difficulty, is at once solved.

The trial heading has been driven about 2,000 yards. The pistons of the boring machine when running at 125 revolutions per minute, cutting off at ⅔ stroke, have consumed about 250 cubic feet of air at 30 lbs., = 750 cubic feet per minute at the atmospheric pressure. About 20 men were at work, and temperatures have been taken with the following results:—

Date.	Shaft Bottom. Return Air.	1,000 Yards Inbye.	2,000 Yards Inbye.	Remarks.
1882.	Deg	Deg.	Deg	
July 3 ...	65	55	52	Boring machine working.
„ 4 ...	65	54	53	Do. do.
„ 5 ...	67	57	55	Do. standing.
„ 6 ...	66	54	50	Do. working fast.
„ 7 ...	68	55	53	Do. working.
„ 10 ..	67	56	52	Do. do.
„ 11 ...	67	56	53	Do. do.
Average...	66½	55	52¼	

The natural temperature of the strata was also taken by a borehole 5 feet deep carefully plugged, and was found to be 52 degrees.

When the haulage engines are running the quantity of air at atmospheric pressure will not be less than 5,000 cubic feet per minute, with an increase as the number of engines is increased.

If such engines as are here described are used for the permanent traffic, each in running through the tunnel will exhaust $\frac{50 \text{ cub. ft.} \times 22 \text{ m.} \times 68}{30 \text{ m.}} =$ 2,493 cubic feet of free air per minute, and this with trains each way every quarter of an hour would give 9,972 cubic feet per minute, or say 10,000 cubic feet per minute, in each tunnel.

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It will no doubt be desirable to have fans connected with each tunnel in case of any stoppage or of any large number of workmen being employed, and assuming the required quantity to be 50,000 cubic feet per minute, and the tunnel to be 14 feet in diameter and 24 miles long, the horse-power necessary will be found by the usual formula.

$$p = \frac{k\,s\,v^3}{a}$$

where p = feet of air column.
k = co-efficient of friction.
v = velocity of current in 1,000 deg. of feet.
a = area of tunnel.
s = rubbing surface in tunnel in feet.

$$p = \frac{0{\cdot}03 \times 5{,}575{,}680 \times {\cdot}105}{154} = 114.$$

Weight of air = $114 \times {\cdot}076 = 8{\cdot}66.$

Horse-power $= \frac{50{,}000 \times 8{\cdot}66}{33{,}000} = 13{\cdot}1.$

50 per cent. useful effect = $13{\cdot}1 \times 2 = 26{\cdot}2.$

The writer has endeavoured to show that Sir Edward Watkin and the Submarine Company have, with admirable judgment, commenced this work, perhaps the most important railway work of the time; the stratum, which combines all the characteristics necessary for success, and the progress already made on both sides of the Channel point to the conclusion that it may, by means of the boring machinery which has been at work for some months, be carried through in an exceedingly short period and therefore at a low cost.

The writer agrees with Mr. Morrison and the other engineers who, in discussing his paper, maintained that the use of the ordinary locomotive in such tunnels would be practically impossible; but he believes that the further development of compressed air, which has been in use for so many years for underground haulage, will be available for any amount of traffic, at a cost very slightly in excess of the ordinary locomotive; at the same time making the atmosphere of the tunnel purer than that of any existing tunnel.

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The PRESIDENT said, they had all listened with great interest to the admirable paper read by Mr. Tylden-Wright, and he had great pleasure in proposing a vote of thanks to him. The question of the formation of the tunnel was of very great interest to them, both as mechanical and mining engineers, bringing as it did before them so many great difficulties for all classes of engineers.

Mr. WM. COCHRANE seconded the motion, which was unanimously agreed to.

Mr. A. L. STEAVENSON said, the first thing which struck him in the paper was that the tunnel was to be carried at a depth of 150 feet below the sea bottom, which, he considered, was amply sufficient to resist the inbreak of water from above, and the strata in which the tunnel was driven was of such a character as to render the risk from any serious inundation of water very inconsiderable. There might be, however, what were called "backs," or "openings," which would put an end to the work; but of course this was a point which could not be decided without a trial. The next point which seemed to him as being good was making the underlevel drifts so as to conduct the water which might leak through to a given point, for it would be decidedly better having it lifted directly by pumps, than having to draw it through long pipes leading into the tunnel. The writer of the paper stated that "on the English side it is dry, except at joints;" and that was the only point which he (Mr. Steavenson) thought was likely to cause any serious difficulty. It was stated that the tunnel would have to be lined. That, he thought, was very probable; and the worst feature of that was that it would take as long to line as to drive it. With regard to haulage, it would be quite impossible to use locomotives of the ordinary type, and the use of compressed air would be absolutely necessary; and, in this matter, it was not a question of the results of one system competing against another system. Colonel Beaumont evidently had this matter all to himself, and no other system would be practicable. As to bringing out the material from the face, it would be quite practicable to bring it out by endless rope haulage, which could be done without any difficulty, and he should say that this mode would probably be the cheapest. It was mentioned that in some places 100 tons an hour were drawn by endless ropes. He had, at this moment, an endless rope bringing 210 tons an hour; and the system was quite as practicable for 2,000 yards as it was for 1,000 yards. The writer stated that the air, after being warmed by steam, generated by a slow combustion stove under the foot-plate, is carried thence into the 2-inch cylinders, these, as well as the 7-inch cylinders, being steam-jacketed. It was not

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sufficiently explained where the steam came from, or how the noxious elements connected with its heating were dealt with. He had not had time to look into the figures given in the paper; but it did seem to him strange, at first sight, that only 26·2 horse-power was required to ventilate a tunnel about twenty miles long; but, taking the figures given as correct, the result stated seemed realizable. If, on investigation, the formula be proved to be as given in the paper, there would be no difficulty in ventilating the tunnel. He did not know whether it was within their province as mining and mechanical engineers to consider the question of the destruction of the tunnel; but he thought, if necessary, it could easily be destroyed by powder, fired either from London, Liverpool, or France, or any point that might be considered beyond the reach of treachery.

Sir EDWARD WATKIN, Bart., M.P., said, he had been requested by those who had been associated with him for some time making the experiments, in such a way as to show the practicability or otherwise of making a tunnel under the Channel, to perform a very pleasing duty, and that was to invite the members of this noble Institution to take an early opportunity of seeing the work which had been done. If the Council of the Institute would induce the members to pay a visit to the tunnel to see the work, he would be very glad indeed to facilitate their visit by the South Eastern Railway, and to make the journey as pleasant as he hoped it would be profitable. All they had now to do was to look at the practical side of the question. He had studied the matter for about twenty years. He was first induced to give his attention to it when he was in Paris with the late Mr. Cobden during the discussion of the Treaty of Commerce; and at that time there were no objections to the tunnel. Since then people arose who looked upon this tunnel business as a very wicked thing. He would not speak of the wickedness, but only of the possibility of the work. The possibility rested, as all grand things did, within a simple compass. It was altogether a question of the stratum through which the works could be forced. Could they have a stratification almost free from water? The theory of the promoters was that they had found in the grey chalk, a non-water bearing stratum, and they simply followed it. The only difference between those who worked with him and some other engineers in Great George Street was, that he proposed to follow nature where it enabled the work to be done, and they proposed to fight nature. Upon the edge of the saucer of this grey chalk there were certain little faults; but, so far as the experiment had gone, in the great flat bottom of the Channel, there was no water at all. They had

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prosecuted the heading under the sea 2,030 yards, and had never had to pump. What little water had been found on the edge of the saucer had been bailed out, and, it was so small that, they might say it was, practically speaking, dry. If they could make the tunnel in the dry it was a feasible and practicable work. The machine of Colonel Beaumont did him infinite credit, and it would be useful for a great many purposes besides making the Channel tunnel. That machine enabled them to cut the tunnel cheaply and quickly; it enabled them to make the work as they made the tunnel. Many people, who had not studied the question, talked a great deal about the difficulties and the enormous cost. By many the cost was put down at £40,000,000; some at £8,000,000; and some assumed £4,000,000, but, for various reasons, doubled that estimate. He would, however, confidently state that the cost of the tunnel, including the land approaches, would be £3,000,000 at the outside; and the time for making it would be four years at the longest. They had got a stratum which was evidently satisfactory to work in; they had got machines; and they had now gained experience which led them to believe that the figures given were correct. A distinguished north countryman, and a member of this Institute, Sir George Elliot, had inspected the tunnel works. Another distinguished man, Sir Hussey Vivian, who, like Sir George Elliot, had been connected with mining all his life, saw the works with Mr. and Mrs. Gladstone. Sir Hussey told him, as Sir George Elliot had also, that he had seen mining all his life, and never had seen such a material to work in as that which they were now piercing under the sea. This work was, with him, not a labour of profit, but a labour of love; and, whatever anyone might say about the wickedness of the work, it would not deter him from trying to carry it out

The PRESIDENT said, he felt quite sure that the Council of the Institute would be very happy, on behalf of the members, to accept Sir Edward Watkin's invitation, and the Secretary would arrange for carrying out the visit.

Mr. WM. COCHRANE said, he would like to know whether the writer of the paper had contemplated the occurrence of any gas—stythe or explosive gas, probably the former. If the stratum be as described, and if found to be so fortunately free from faults and leaders, as Sir Edward Watkin and the writer of the paper were so sanguine as to expect, the making of the tunnel was practically a success, he did not see how anyone could dispute that; but they would be fortunate if they found, in a distance of about twenty miles, that the course was uninterrupted by any such difficulties. The great merit of the promoters was that they had been

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able to discover the grey chalk strata to be of the nature described. When he was making a tunnel in the chalk beds under the sea at Copenhagen, operations went on for a considerable time, until, owing to fissures yielding heavy feeders of water, the work had to be abandoned; subsequently, costly pumping arrangements were made, and the tunnel was completed. He hoped such difficulties would not be met with in the Channel tunnel.

Sir Edward Watkin said, that geologists knew that in olden times England and France were connected together, and the bottom of the Channel had been ground out by the passage of icebergs from the North Sea. The grey chalk was impervious to water, because it was a mixture of 65 per cent. of chalk, and 35 per cent. of clay, and it was entirely puddle-hardened. That was the secret of the whole thing.

Colonel Beaumont said, that after the very exhaustive details given by Mr. Tylden-Wright in his excellent paper, he did not intend to trouble the meeting with any very elaborate discussion of the mechanical aspect of this great question. He was happy to think that the subject was now in a very widely different position to what it was three or four years ago, when he first became connected with it. At that time people laughed at the idea of making the Channel tunnel, and they treated it as they did the flying-machine, as a chimerical proposal. All that had been met by the magician's wand, waved by Sir Edward Watkin; and now they heard no more of the impracticability or impossibility of the work, but they did hear people say that the tunnel was not a thing which the country required, and here he would simply remark that the tunnel when it was made, especially so far as the land approach was concerned, might be destroyed with perfect facility; that was to say, it did not depend upon the will of two or three people, or upon three or four different arrangements that might have to be made, but it was absolutely and certainly within the power of those who had control of the operations to destroy the tunnel when it had been made by a choice of many alternative means. To turn to the mechanical points that had been raised, Mr. Tylden-Wright had referred to the air locomotive with which his (Colonel Beaumont's) name had been connected; and a question had been asked how the heat necessary for jacketing was supplied? It was supplied by a small slow-combustion boiler, not much larger than a man's hat, and the amount of heat required was comparatively small. There was no doubt there would be an objection to the consumption of a large quantity of coal, but that objection ceased when the quantity of coal or coke was reduced to the extremely small amount which was required to supply the steam necessary for the steam-jacketing outside the cylinders. Another question,

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asked by Mr. Cochrane, was as to the possibility of the stratum continuing as it had been described, viz., one of grey chalk entirely unbroken. He quite agreed that it was extremely improbable that such a continuous stratum should exist so far as the evidence of what had already been executed elsewhere was concerned; but he would ask them to bear in mind that twenty or thirty miles of tunnel driving in chalk had never yet been effected. In evidence of the probability of this stratum remaining continuous, he might state that soundings had been taken across the bed of the channel, 5,000 or 6,000 in number, and these soundings showed that it was continuous and without a break. They would no doubt say that, though the surface of the stratum might be continuous, there might be some breaks in it, and that the breaks would let in the water. In the case of hard rock, such as sandstone, this would be the case, but he thought that would not be found to be so in a substance so elastic as the chalk measures seemed to be. In the 3,000 yards already driven they found "backs," clearly defined; that is the strata were raised on one side, and lowered on the other, and yet they allowed next to no water to pass through. In further confirmation of this, he might mention what seemed to be satisfactory evidence of the probable success of the undertaking. On the French side, lately, his machine had cut, from the lower measure of the grey chalk, through the upper green sand, into the gault, and, notwithstanding that, there had been no water. Consequently it appeared to him they had perforated every sort of strata likely to be met with, and yet the quantity of water met with had been insignificant. While the heading had been driven with explosives on the French side, the discharge was one-fifth of a gallon for each metre of gallery that was opened. They found, as a fact, as the mechanical boring continued, even when the machine passed through the grey chalk into the gault, that the water diminished, and became all but insignificant. As to the tunnel-driving machine with which his and Captain English's names were associated, and the using of it for driving in other rocks, he thought the Channel tunnel and the whole of the works in connection with it would be finished in three or four years, and the headings might be made to connect in two years from the present time; and, so far as his machine was concerned, there would be an end of it; but he thought there was a bigger future before it. The machine had been tried in the hard sandstone rock of the Woodhead tunnel, which passed through the back-bone of England, between Sheffield and Manchester; and the character of the grit rock, from the summit of that ridge of hills, was exceedingly difficult to drive. It was not so much the hard character of the rock, as its gritty nature which destroyed the tools. The machine had been tried

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there, and the result had been to show that all the rocks of the sandstone measure and rocks up to that degree of hardness could be perforated without explosives; and by the use of dead pressure alone applied to the cutters, passed through at the rate of one foot per hour. He ventured to say that, supposing the Channel tunnel were to be stopped altogether, this one result, which certainly had been the outcome of the experiments, would show that the machine made for the Channel tunnel would have a very important future. The action of the machine was, that a very heavy pressure was put upon the tools, and portions of the rocks were punched or forced off, rather than disintegrated by means of abrasions. The importance of such a machine, which could be used in driving in fiery mines, could not be over-estimated, but, before it could be generally employed, it would be necessary that more experience should be obtained.

Mr. WARINGTON SMYTH said, Mr. Wright's paper opened out so many questions that it was with some difficulty he rose to make a few observations upon one or two points. He owed it to the courtesy of Sir Edward Watkin that he had been enabled to examine the works of the Channel tunnel. He believed they were quite aware of how much had been done by the individual energy of character and perseverance of Sir Edward. The first thing which struck him was as to the strata through which the tunnel had been so far carried, and he must say, with some experience of drifts carried through different classes of rock, some under land and some under the sea, it never fell to his lot to see a more remarkable driving of 2,000 yards in extent with scarcely sufficient water to wet the finger. Standing in the trial tunnel was very much like standing in the tube of a gigantic telescope. That was due in part to the character of the strata and in part to the excellence of the work performed by Colonel Beaumont's machine. He need scarcely, he thought, do more than endorse Colonel Beaumont's observations. In crossing for a distance of upwards of twenty miles, it is quite certain that a succession of faults and troubles of various kinds would be met with; but from what had been seen already, he was confident that, although they might be numerous, and although they might be accompanied in many cases with a throw of the strata, generally to a small extent, still the character of the rock was such, partly from the mobility of the particles and density of the mass, and also its water-resisting character, that one naturally expected that these troubles would be packed so closely together as to resist, to a very great extent, the entry of water into any work carried out under the sea. He was sure the President, from the experience he had had in working coal under the sea, where much harder strata were found, would bear him out that if this were intersected by rock which

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stood open, a soft material would fall in and have a tendency to press together and so prevent any danger of inundation. If any further illustration were wanting to show the impracticability, he would say the impossibility, of the ordinary railway locomotive being used for traction purposes in the tunnel, he might give one in the shape of a little excursion which he made last week in the Laxey Mine, in the Isle of Man. He rode for a distance of a mile in a drift which was between three and four feet wide and seven feet high on the average, and every time fresh coal was put on, the cloud of mixed steam, reek, and smoke in which they were enveloped was such as to show that an ordinary locomotive was intolerable for one mile, and for a greater distance no one could dream of using it. Hence they had no alternative but to use in the tunnel compressed air locomotives, which had been brought forward by Colonel Beaumont. He would not attempt to go into some of the subjects which invited attention, but he might say that what had been stated by Colonel Beaumont was, he was sure, of the very greatest interest to mining men, namely, that this machine had been found capable not merely of carving its way in the soft material through which the Channel tunnel so far had passed, but also through harder rocks. If Colonel Beaumont could successfully get through the millstone grit of the Woodhead tunnel he had succeeded in what nobody else had done, and the machine would be of the greatest value in driving through stone drifts in fiery mines without the use of explosives.

Mr. E. F. Boyd said, that in his experience of geological questions it had always appeared to him that the extent of the "faults" to be met with diminished in the upper strata as compared with the lower ones; and if that were the case they would expect the quantity of water to be met with less likely to interfere with the work in the chalk formation than in the lower strata.

Mr. Tylden-Wright said, he thought the only question which Colonel Beaumont had left for him to answer was as to gas. The tunnel had, he thought, taken nine months to drive, and he was informed that no gas of any sort had been met with in it; but even if there had been any gas, he was sure Mr. Cochrane would supply both lamps and ventilators that would very soon render any danger from gas of no account at all. He had been in the tunnel with fifty people, when the engine was standing and comparatively no air coming from it, and, notwithstanding, the air was sweet, nobody had a headache, and the people were more comfortable than in any railway tunnel at present in existence. He was much obliged to them for the way in which his paper had been received.

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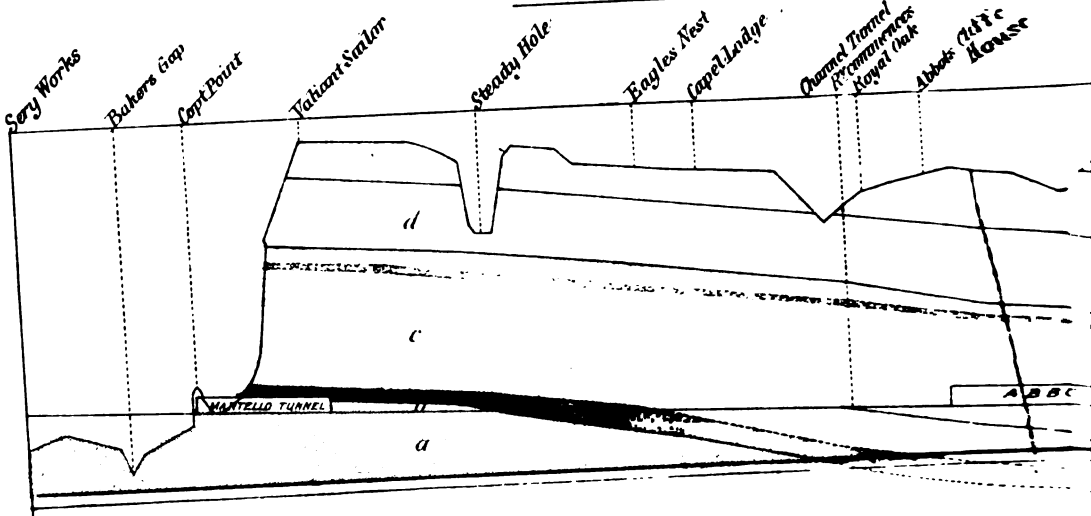
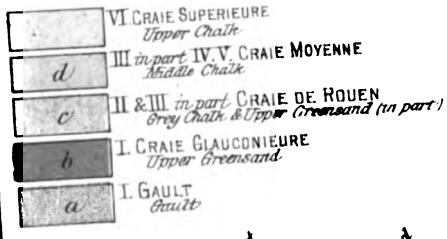
To illustrate Mr. Charles Tylden's





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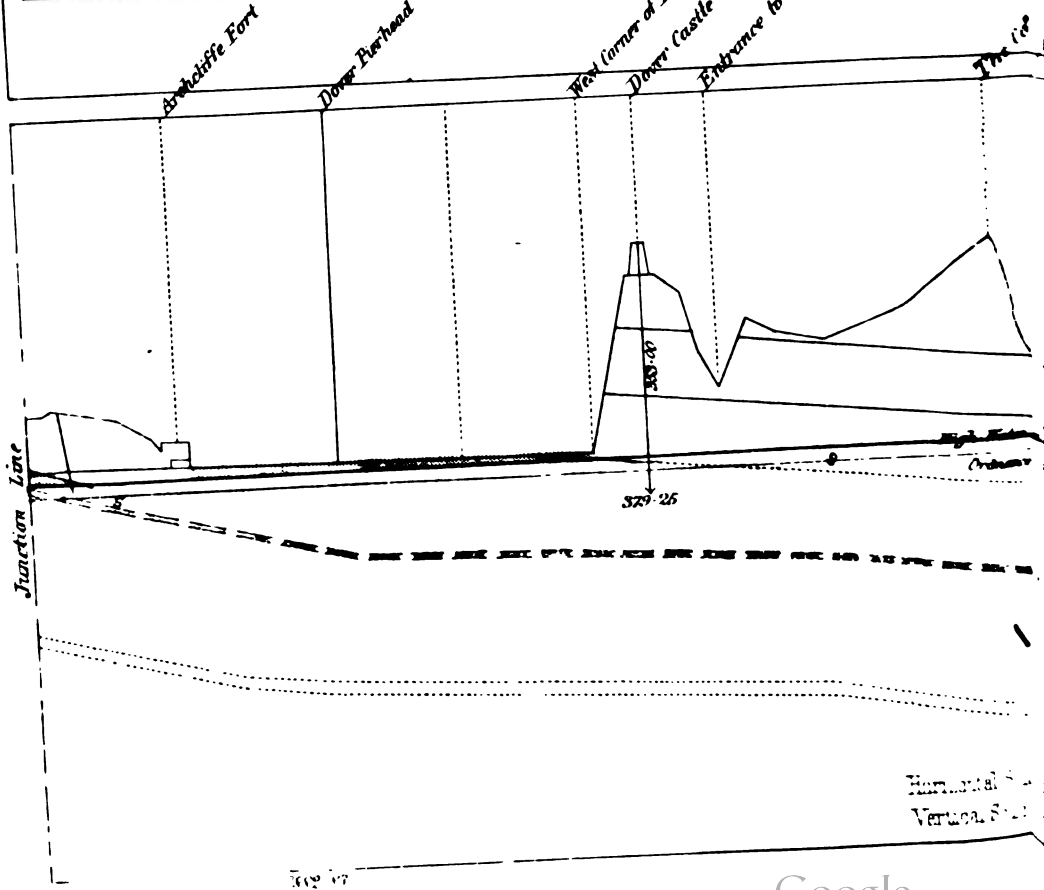

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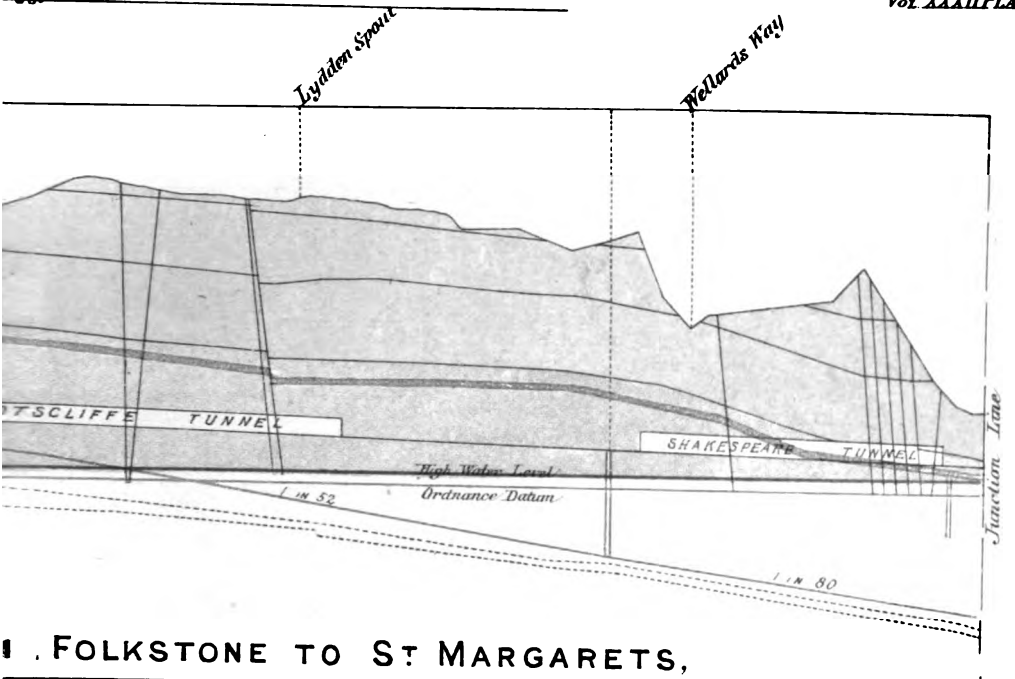

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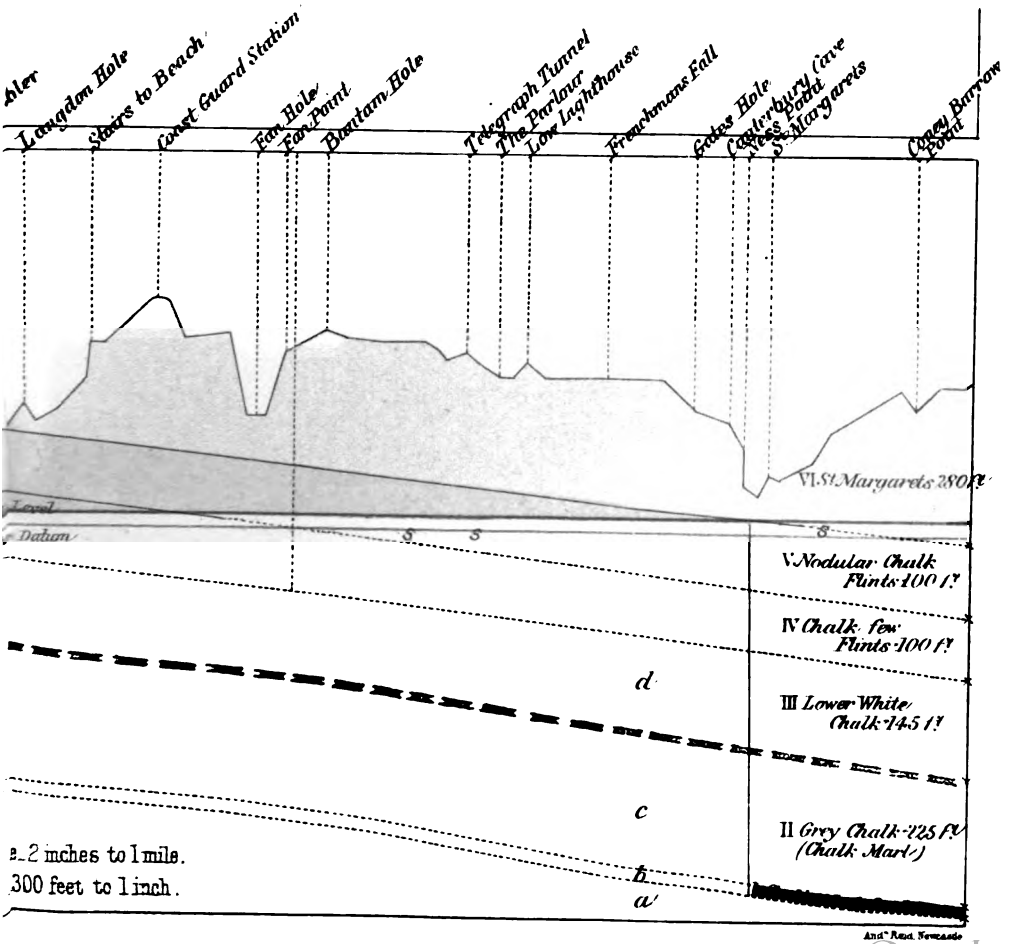

2 inches to 1 mile.
300 feet to 1 inch.

And. Reid. Newcastle

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To illustrate Mr Charles Tylden-M

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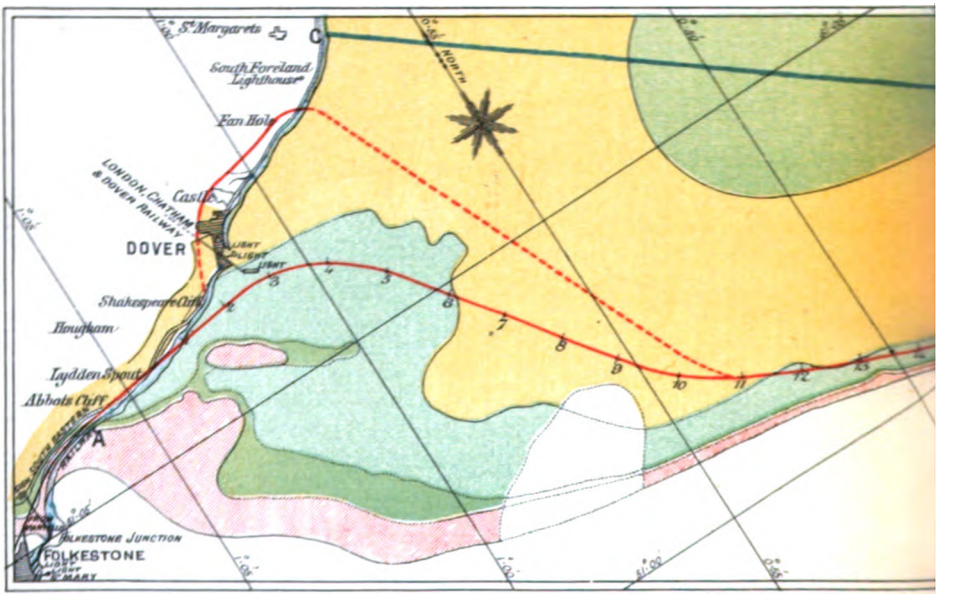

Scale of English Miles

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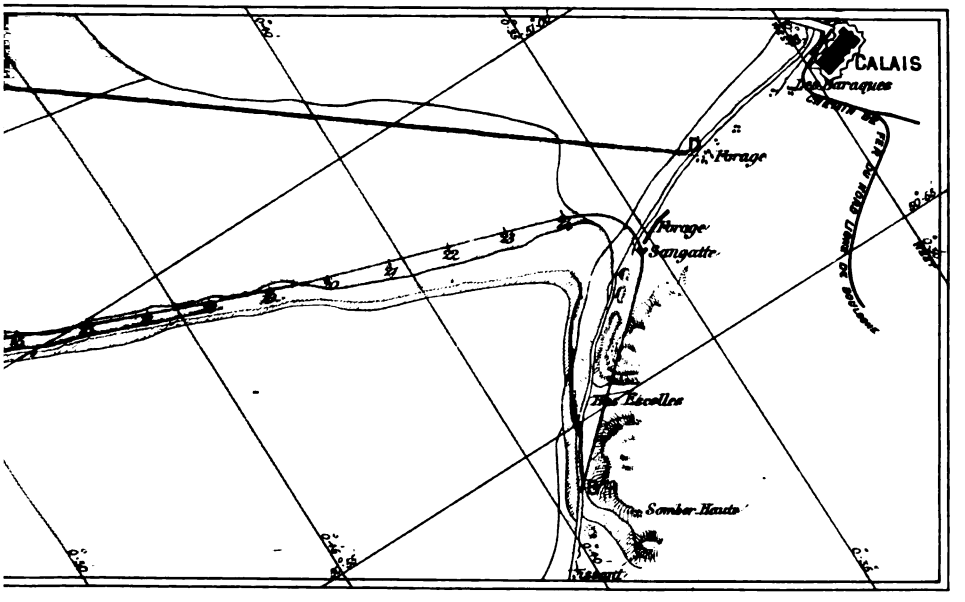
ght's paper on "The Channel Tunnel."

rween Dover and Calais.



Craie Supérieure
Upper Chalk

Craie Moyenne
Middle Chalk

Craie de Rouen
Grey Chalk & Upper Greensand (in part)

Craie Glauconieuse proprement dite
Upper Greensand

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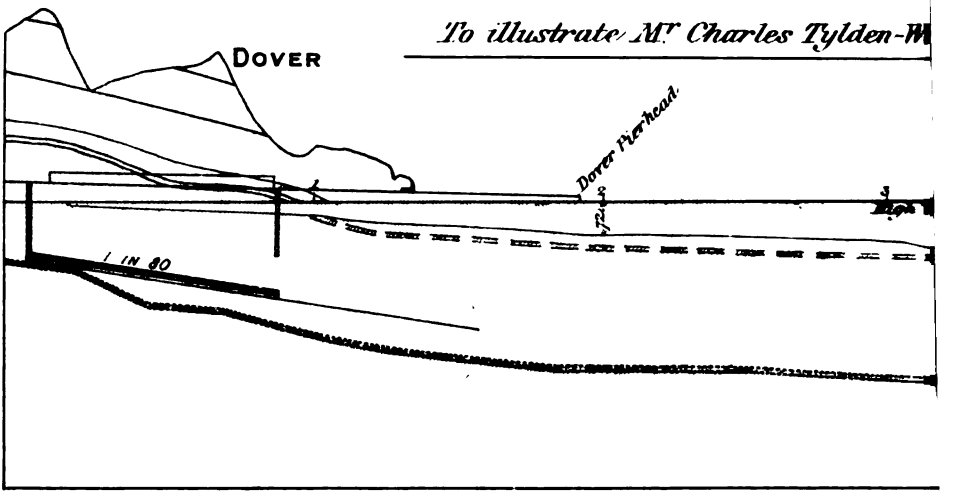

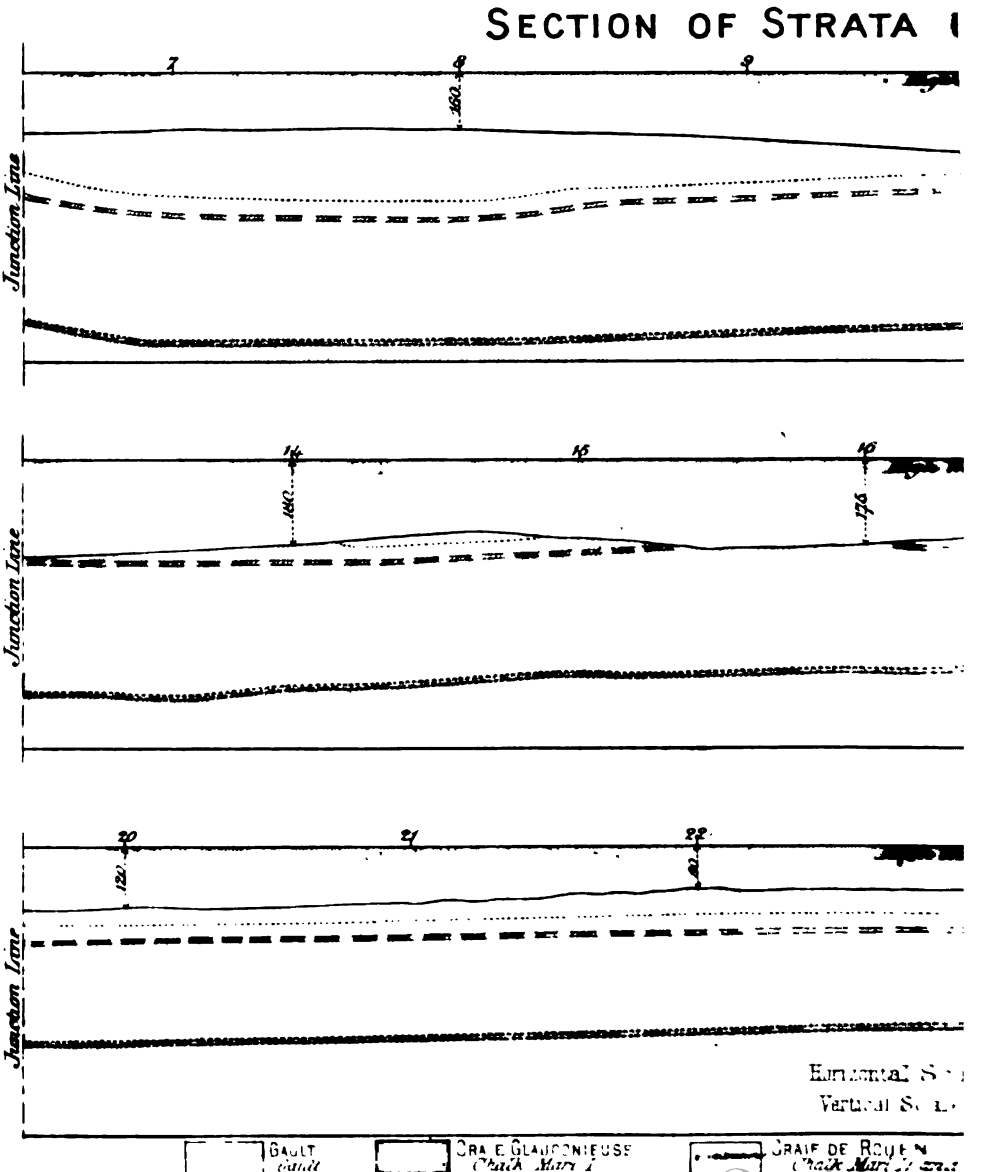

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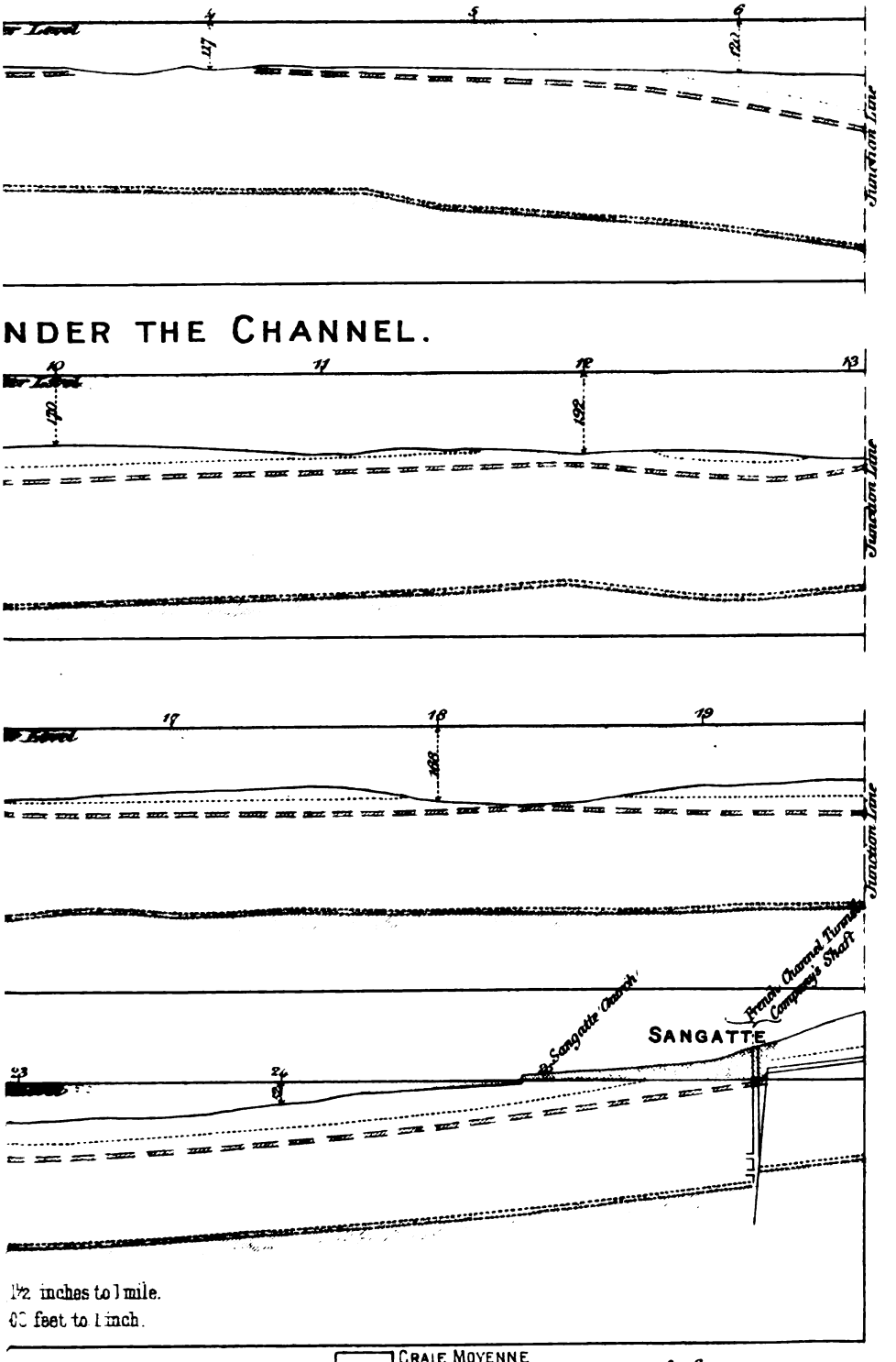

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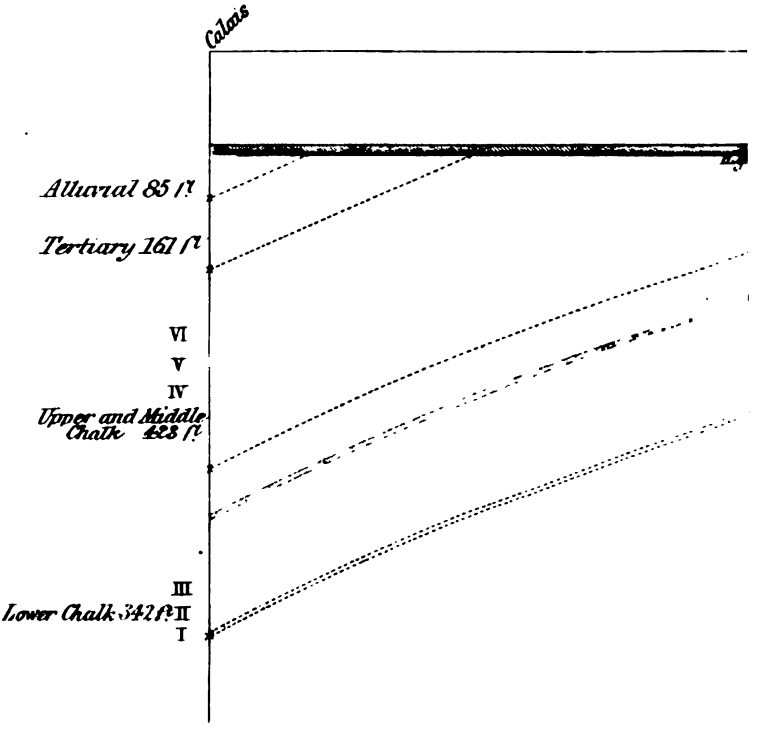

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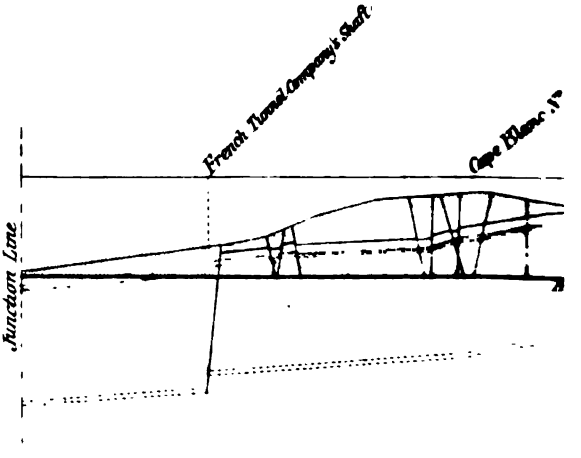

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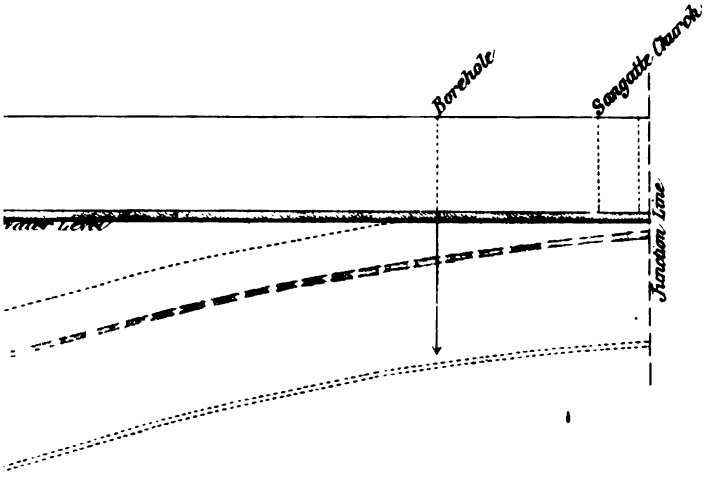

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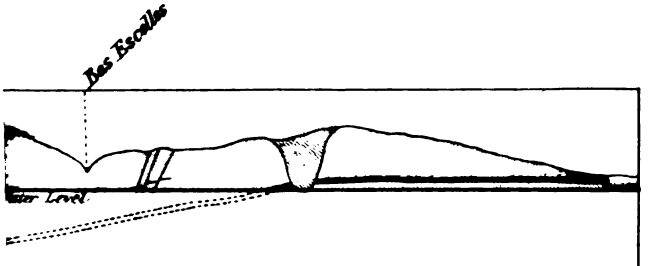

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To illustrate Mr. Charles Tylden-Wr

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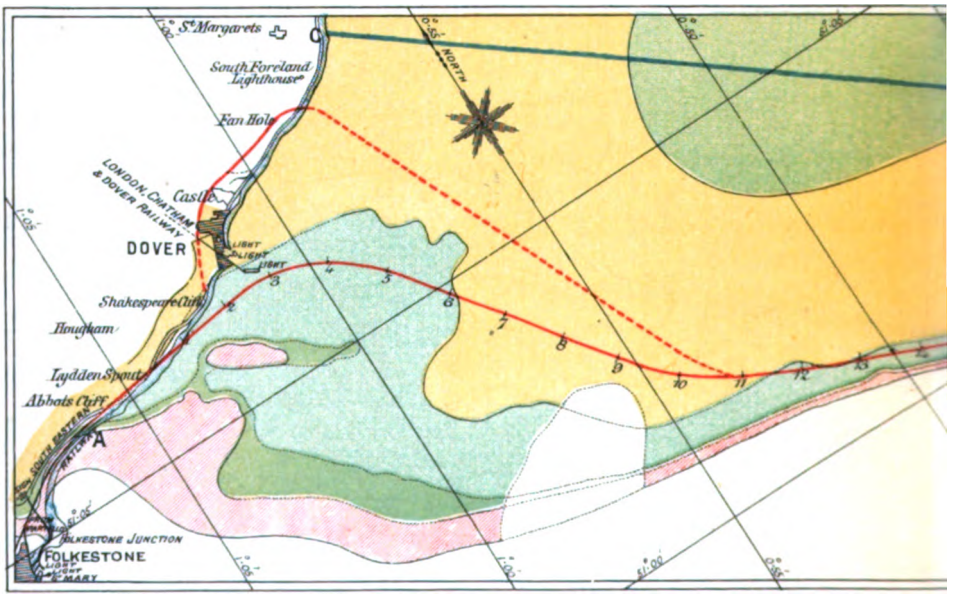

Scale of English Miles

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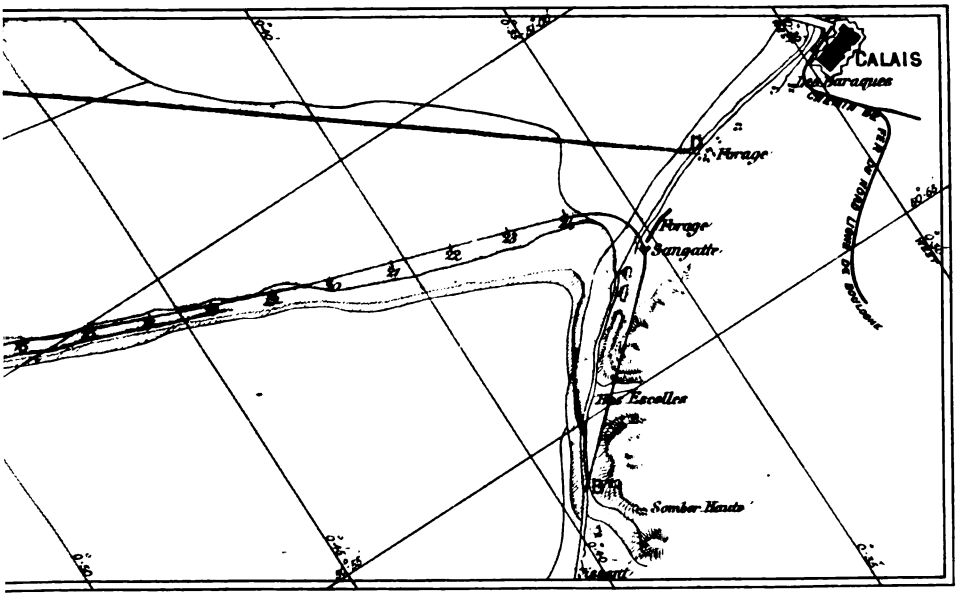

CRAIE SUPÉRIEURE
Upper Chalk

CRAIE MOYENNE
Middle Chalk

CRAIE DE ROUEN
Grey Chalk & Upper Greensand (in part)

CRAIE GLAUCONIEUSE PROPREMENT DITE
Upper Greensand

GAULT
Gault

And.w Reid Newcastle

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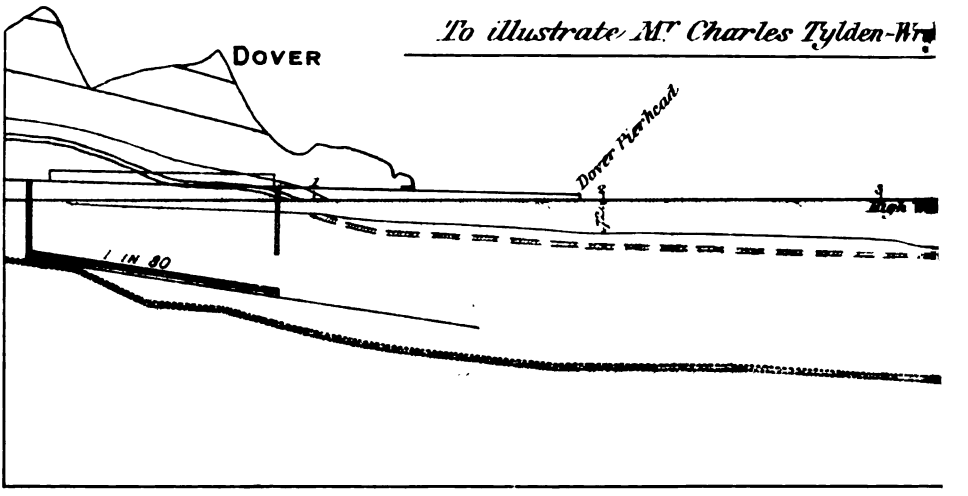
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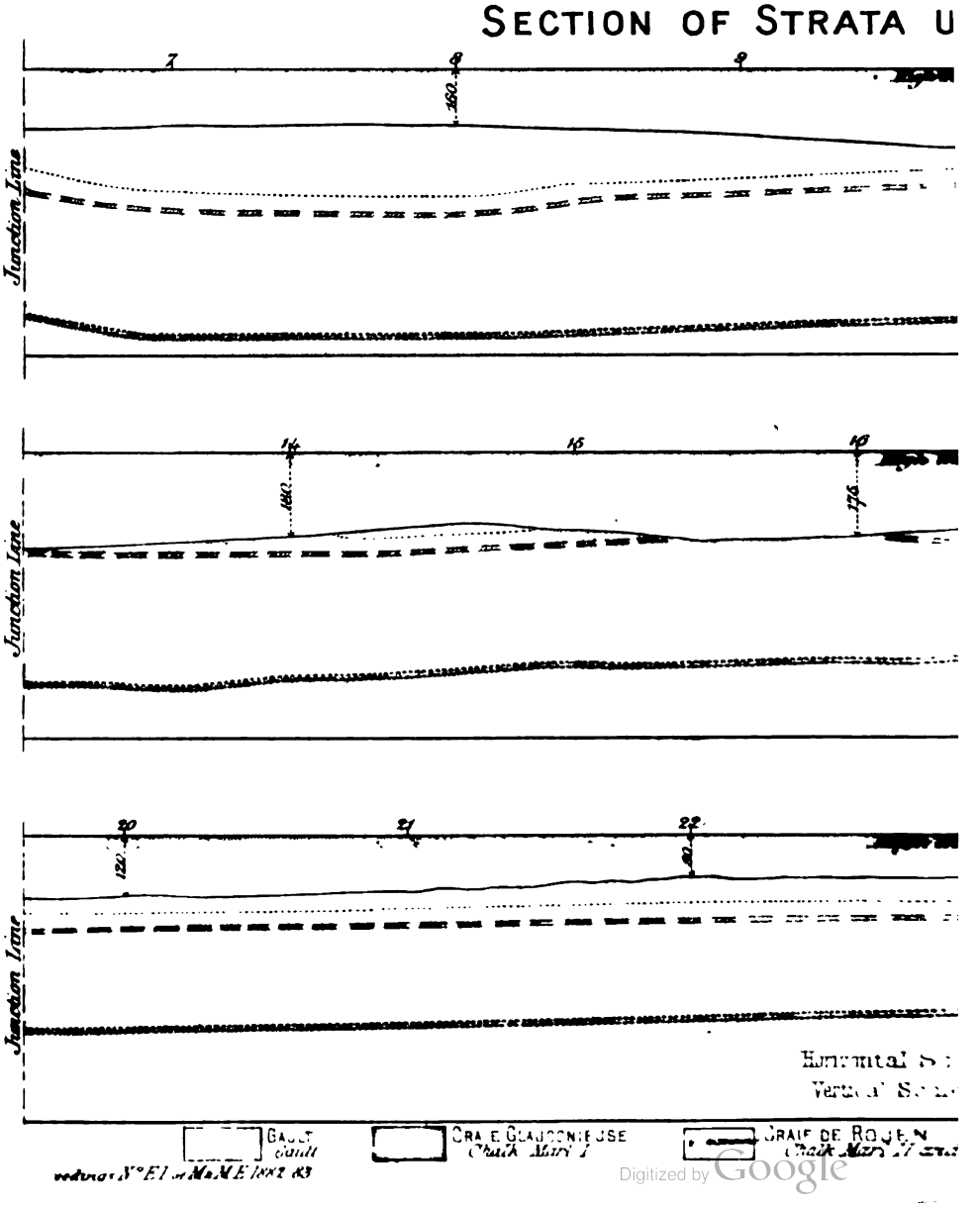
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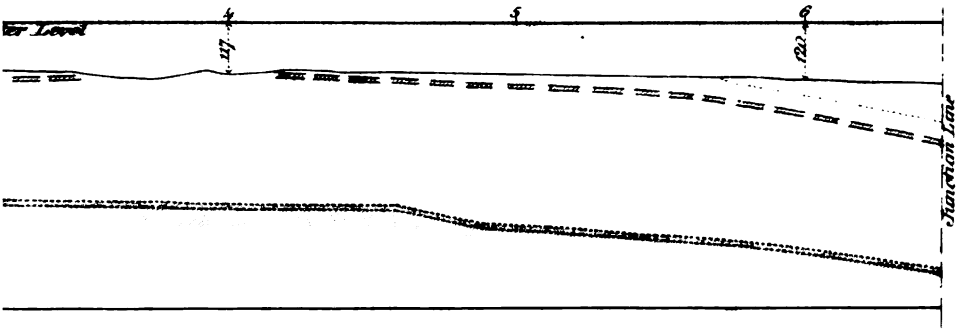

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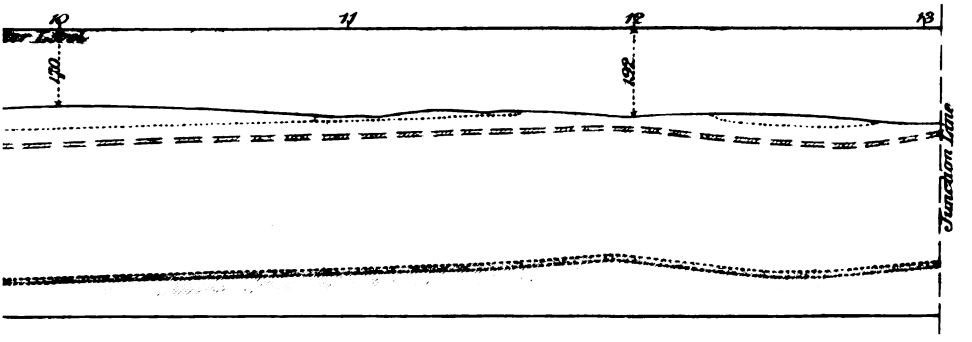

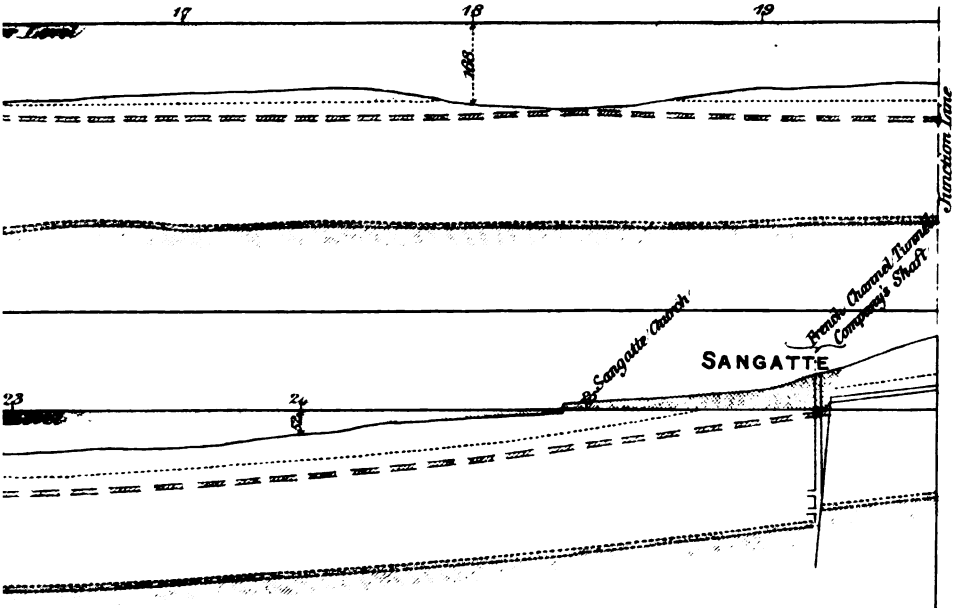

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CRAIE MOYENNE
Lower White Chalk in part with few flints

And.ᵂ Reid Newcastle

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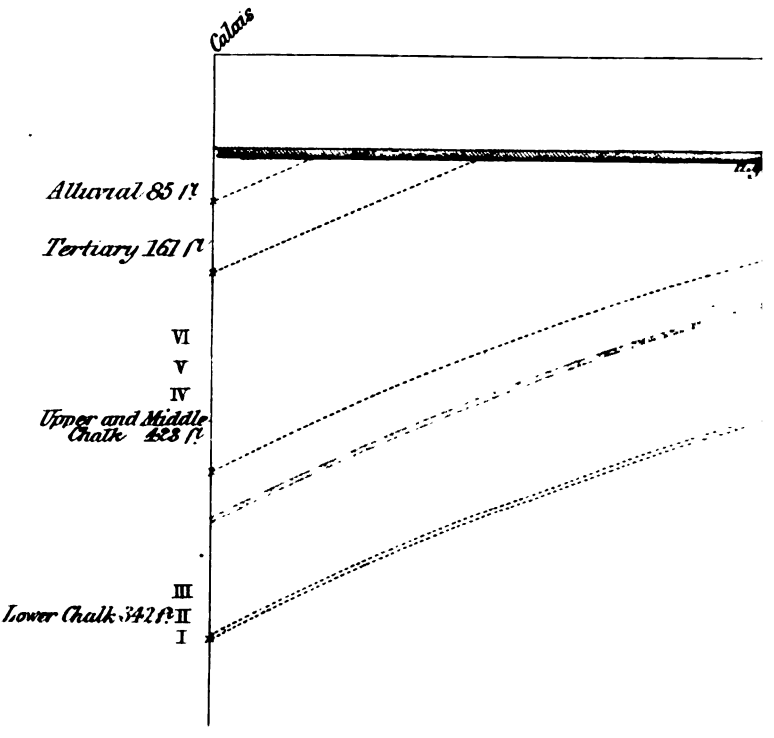

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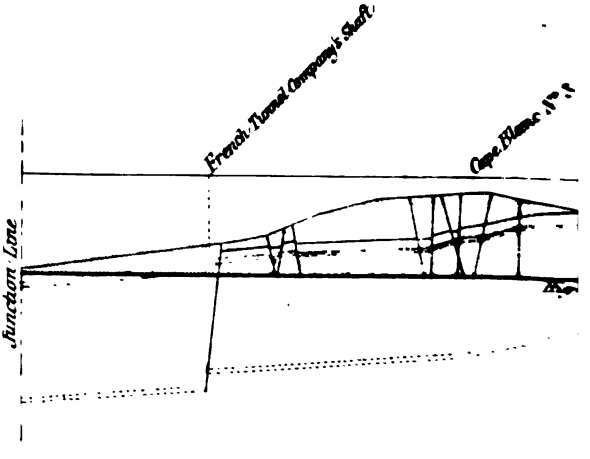

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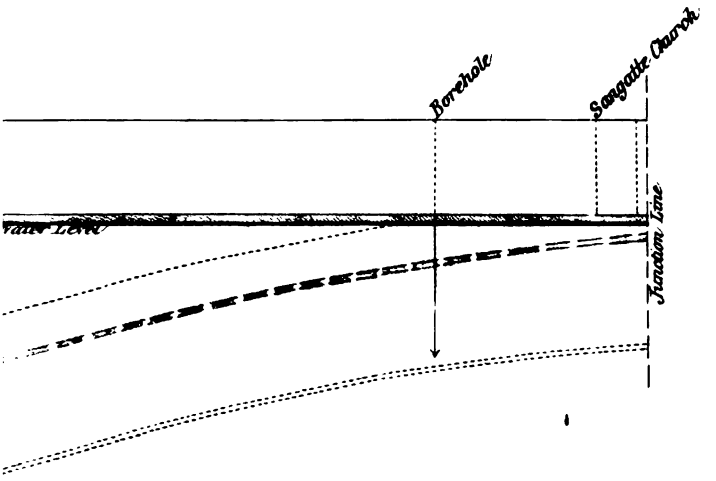

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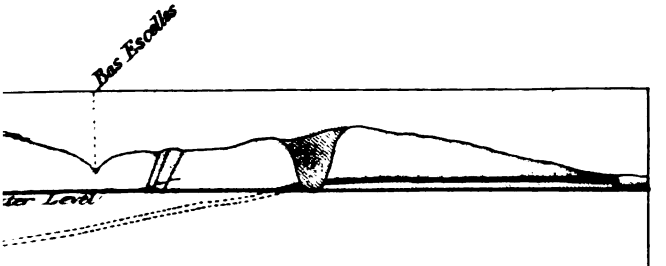

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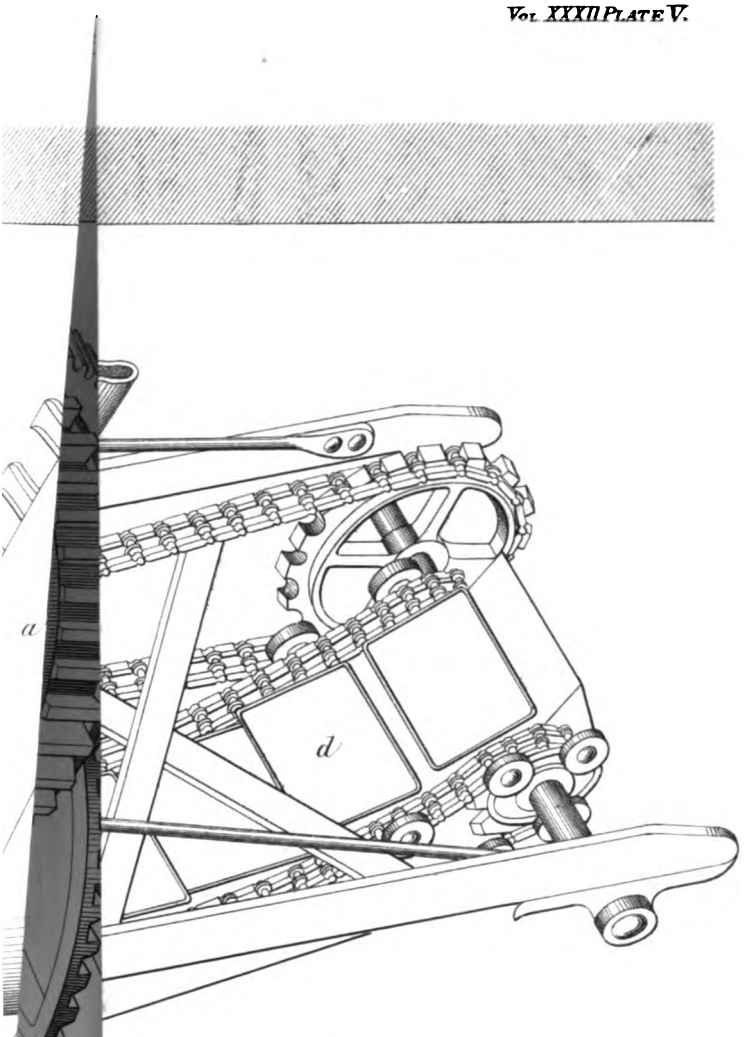

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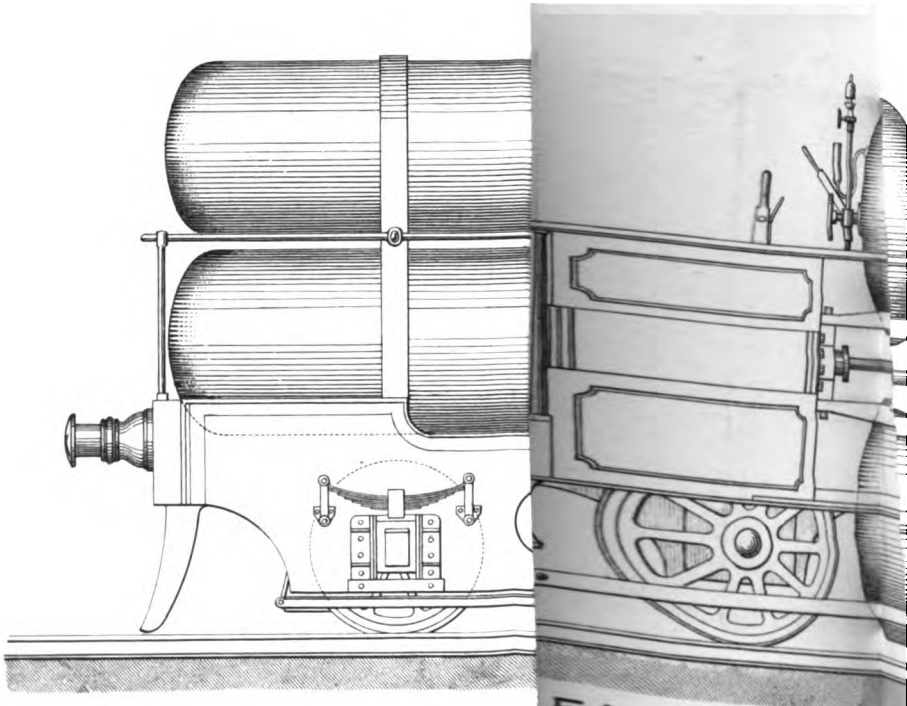
Mr. Charles Tylden-Wr



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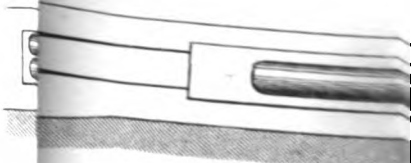

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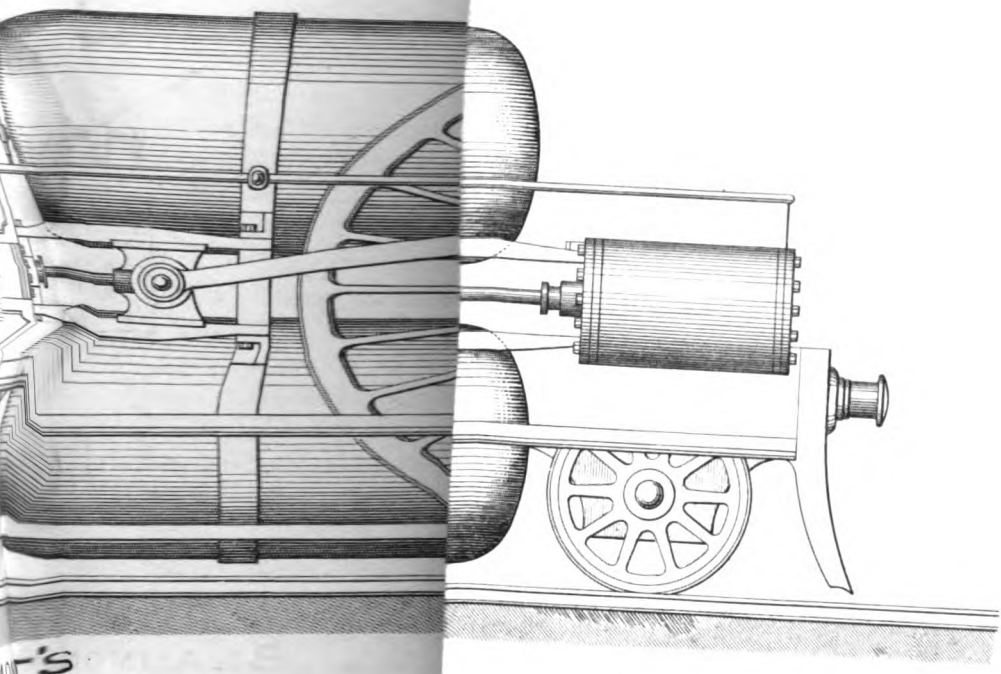

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The PRESIDENT said that, in accordance with the custom of the Institute, the discussion of the paper would be adjourned until further notice. He moved a cordial vote of thanks to Sir Edward Watkin, Mr. Warington Smyth, and Colonel Beaumont, for their kindness in attending the meeting to tell the members about a matter which so much interested them. He had been connected with mining under the sea for a number of years, in places where the distances were reckoned by miles, rather than by hundreds of yards; and, having seen workings carried out with success in the face of great difficulties, from both water and gas, he saw no engineering reason why the Channel tunnel should not be prosecuted, if the data given in the paper held good, and he was sure that the admirable arrangement of the air machines must very greatly conduce to that end. They were doubly indebted to Colonel Beaumont for bringing before them the use of compressed air in mines, which was increasing every year. If the machine could be made to take the place of hand labour they would save an immense cost in time, and it would also enable them to work safely in places where there was fear of inflammable gas.

Mr. T. J. BEWICK seconded the vote of thanks. He said Colonel Beaumont's machine had been tried at the Woodhead tunnel, in, he might say, almost the hardest sandstone rock, harder, he thought, than any in Northumberland. He regretted that he (Mr. Bewick) had not brought some of the specimens which he had the opportunity of taking last week, when he saw the machine at work. It was quite certain that the machine was capable of going through very much harder strata than that which it had to contend with in the Channel tunnel, and which seemed in fact to be child's play in comparison with the hard rocks occurring at many other places. If Colonel Beaumont would perfect his machine, as he (Mr. Bewick) believed he could, to drive tunnels such as that at Woodhead, he certainly would overcome difficulties of no ordinary character in the formation of tunnels, and it would lead to a complete revolution in driving stone drifts in fiery mines, which, at the present time, could not be done without the use of explosives. He had not had the pleasure of seeing the Channel tunnel, but he hoped to be one of the members of the Institute who would accept Sir Edward Watkin's kind invitation to visit the works at Dover.

The motion was agreed to.

Sir EDWARD WATKIN thanked the meeting for the courtesy with which they had received him and listened to his explanation.

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The discussion of Mr. T. J. Bowlker's paper, Description of a New Ventilating Fan, next took place.

Mr. BOWLKER said that some members had remarked at the last meeting that the fan was of the open circumference type; this was not so, the fan was not at all of the open circumference type, but entirely of the close type. The Guibal fan was a closed fan, and formerly it was the the great boast that, being closed in all ways, a much higher water-gauge could be obtained, and that its efficiency was greater than that of the open-running fans. It was argued, and argued rightly, that the Guibal fan, on account of the diminution of pressure which was found in the case ought to give a greater useful effect than other fans. In practice, however, it had been found that those other fans gave a percentage of useful effect differing hardly, if at all, from that given by the Guibal. The reason of that was no doubt due to the air friction inside the Guibal fan. The fan which had just been brought out did away with that air friction to a very great extent, and therefore it had not that source of loss which was inherent to the Guibal fan, while at the same time it had got a superior water-gauge.

Mr. WM. COCHRANE said he had previously in the discussion of the paper pointed out what he considered some of the objections to the system proposed, and what he had to say now was only confirmatory of those comments. It was much to be regretted that the Bowlker 8½ feet fan was not tested with an evasée chimney of the perfect Guibal type, properly adjusted, for, in his opinion, no other comparison was satisfactory. Mr. Bowlker omits all considerations of the difference of conditions of the Rockingham and Byron Collieries ventilation, in which may be involved the ten to fifteen per cent. of different useful effect, supposing it is a fact, $\frac{V^2}{h}$ being relatively in one case $\frac{139^2}{1{\cdot}35}$, and in the other $\frac{19{\cdot}737^2}{1{\cdot}35}$ for the importance of which he referred the members to previous Transactions, and, for a practical illustration, he need not go beyond the record of the Rockingham ventilator itself, where, as would be seen on page 94, Vol. XXXI., with more favourable conditions of the mine, 165,400 cubic feet passed through the fan at 1·90 water-gauge, at 33 revolutions or 5,000 cubic feet per revolution, and in the experiments for comparison with the Bowlker, tabulated on page 98, at thirty revolutions, only 117,810 cubic feet were passed through, or 3,927 per revolution. It must be evident that these conditions fail to give the best result of the forty-five feet Guibal fan, although they may record the best results under the circumstances of Rockingham ventilation.

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It is noticeable also that the Guibal fan improves in useful effect from 37·4 per cent. to 57·4 per cent. as the speed is increased from 20 to 60. Why were not higher speeds tested? He should expect a correspondingly increased useful effect; whereas the Bowlker was nearly steady at such speeds as 150 to 225, which was, he presumed, nearly its effective maximum. For a fairer comparison, slower speeds of the Bowlker should have been tested, certainly the same speeds of periphery in each case, which would have been about 100 revolutions as the equivalent of the twenty revolutions of the Guibal.

Taking, however, the useful effect of about 63 per cent., he inferred that the Byron conditions of ventilation are very favourable, and he felt sure the properly adjusted Guibal fan would, in this case, have attained such results as have been yielded with 36, 40, and 45 feet diameter Guibal fans at some of the mines in this country, viz., 70 per cent., when volumes of 5,000 to 6,000 cubic feet per revolution of the fan have been passed through it.

The Guibal system was theoretically capable of a much higher useful effect than is obtained in practice, but under ordinarily favourable conditions at least 60 per cent. should be obtained. It must not be forgotten that the type of engine and the finish of the machinery may vary the result at different collieries, and especially where such a contrast is made as a fan 8½ feet diameter dealing with 20,000 cubic feet, and a 45 feet which is proportioned to deal with 250,000 cubic feet.

Hence he failed to see that there was anything in the paper which proved any better result from three evasées than one, because one had not been tried under the same conditions as the three; and as to the theoretical investigation he considered the original basis of the Guibal system, which, as the writer admitted, had led to the construction of a fan superior to all other fans, was directly challenged. The whole question of re-entries of air in centrifugal fans discharging all round into the open air had already been fully discussed in the Proceedings, and practical results are recorded showing how serious is the depreciation of useful effect due to this cause.

When the Guibal casing was designed it was inevitable that the circumferential friction (if he might so define it) should be added to that of the sides, but it was the substitution of a smaller evil for the larger one.

Another objection he had to make to the proposed three evasée outlets was the costly construction, which would far outweigh any such improved useful effect, even if it were established, which he thought had not been the case, and generally he thought it preferable to have a large diameter of fan, with a slow speed of engine, to attain a given water-gauge, rather

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than a small diameter of fan, with an engine running at high speed, where large volumes of air are involved. If an extensive ventilation were in question it would deter anybody from incurring the extra outlay. The value of the adjustment by the sliding shutter had been fully proved in the case of the Guibal system, as well as that of the evasée chimney, and each addition to the open-running fan, by testing one and the same fan in course of construction, and, in his opinion, any departure from the perfected Guibal would only lead to deterioration of useful effect.

Before leaving the subject he desired to acknowledge the careful nature of the investigation, and the ability of the mathematical examination of the element of friction, but the writer of the paper had only been able to arrive at his formula and coefficients by some hypothesis, as did probably Mons. Péclet, a very careful experimenter and an able mathematician. Yet the writer condemns Mon. Péclet's coefficient of ·0217 as utterly erroneous and useless. He (Mr. Cochrane) was therefore led to express the greater confidence in asking the members to suspend their judgment until they had the thoroughly practical result of the same fan tested under the same conditions of mine with the Guibal and the Bowlker system.

Mr. JOHN DAGLISH said, that since the last paper was read they, through the kindness of Mr. Bowlker, had had the fan tested by Mr. Lindsay, and in the same way as he and Mr. Liveing had tested other fans for the Committee, and the following was the result of the experiments:—

EXPERIMENTS WITH BOWLKER'S FAN.

Byron Colliery, Haltwhistle, October 7th, 1882.

The experiments were made at varying speeds of fan, viz.:—

Experiment	A	...	...	...	...	100	revolutions.
Do.	B	...	...	...	...	150	do.
Do.	C	...	...	...	...	200	do.

The air was measured in the fan drift by moving the anemometer carefully over the whole area for three minutes, this was twice repeated with one minute interval, and the mean velocity ascertained from these.

The water-gauge was read on the fan drift doors, there was no appreciable difference between it and the water-gauge on the fan inlet.

During each experiment the speed of the engine did not vary more than one revolution per minute.

All the diagrams were taken from the right-hand cylinder, and several were afterwards taken from the left-hand cylinder at a similar speed and water-gauge.

C. S. LINDSAY.

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EXPERIMENT A.—100 REVOLUTIONS OF FAN PER MINUTE.

	Mean Pressure of Diagram. Right-hand Cylinder.	Revolutions of Engine.	Water-gauge.	Horse-power of Engine.	Horse-power in Air.	Useful Effect. Per Cent.
	Lbs.					
Experiment A_1	9·10	40	0·57			
Do. A_2	9·17	40	0·57			
Do. A_3	9·60	41	0·62			
Do. A_4	9·30	40	0·60			
Total	37·17	161	2·36			
Mean	9·29	40·27	0·59			
Left-hand cylinder ...	8·41					
Mean	8·85	...	...	2·40	1·22	50
EXPERIMENT B.—150 REVOLUTIONS OF FAN PER MINUTE.						
Experiment B_1	17·23	60	1·26			
Do. B_2	17·85	60·25	1·27			
Do. B_3	17·16	60	1·29			
Total	52·24	180·25	3·82			
Mean	17·41	60·08	1·27			
Left-hand cylinder ...	16·18					
Mean	16·79	...	...	6·86	3·97	57·8
EXPERIMENT C.—200 REVOLUTIONS OF FAN PER MINUTE.						
Experiment C_1	29·05	80	2·28			
Do. C_2	28·45	80	2·24			
Do. C_3	29·88	80	2·29			
Total	87·38	240	6·81			
Mean	29·13	80	2·27			
Left-hand cylinder ...	26·51					
Mean	27·82	...	...	15·01	8·5	56·6

RESULTS OF EXPERIMENTS WITH BOWLKER FAN AT BYRON COLLIERY, OCTOBER 7TH, 1882.

No. of Experiment.	Revolutions of Fan.	Mean Water-gauge.	Mean Velocity Air. Fan Drift.	Area of Fan Drift.	Volume of Air. Cubic Feet per Min.	Horse-power in Air.	Revolutions of Engine.	Mean Pressure of Diagram.	Horse-power of Engine.	Useful Effect. Per Cent.
A	100	0·59	219	60	13,140	1·22	40·27	8·85	2·40	50
B	150	1·27	331	60	19,860	3·97	60·08	16·79	6·86	57·8
C	200	2·27	396	60	23,760	8·50	80·	27·82	15·01	56·6

Barometer 29·40″. Thermometer 60° in Fan Drift.

He hoped, in an important matter like this, that the Institute would allow the discussion to be again adjourned, so that they might afterwards be able to consider the extremely interesting remarks made by Mr. Cochrane, and also have before them the results of the experiments

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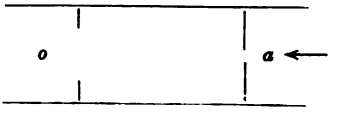
made by Mr. Lindsay to contrast with those Mr. Bowlker had made. The result of the experiments given by Mr. Lindsay did not quite reach the figures given by Mr. Bowlker, but they certainly did represent a high useful effect, he thought, at least, equal to those of any other fan tested, namely, at 150 revolutions of the fan, 57·8 useful effect, and 200 revolutions, 56·6, useful effect. The whole question of fan ventilation was somewhat mysterious. They had one fan doing excellent work in one position, and the same fan giving very different results elsewhere. Possibly, they would never get to the bottom of this until Mr. Cochrane's suggestion was carried out, that the different fans should be tested under exactly the same conditions, and all upon the same pit. All they really wanted was the air in the pit, they did not want it on paper. Many of them could not follow those very intricate calculations; and really, the only practical way of testing a fan was by ascertaining exactly what quantity of air was obtained from it. Mr. Cochrane had spoken of the effect of the shutter. No doubt, as a matter of calculation, and under certain circumstances, where great care had been observed, the shutter had been found to have a beneficial effect; but he was bound to say that, in general practice, they did not find any great benefit from the shutter, and they were not always altering their shutters up and down. In nearly every case the shutter was a fixture, and he could not say that, practically, they obtained that benefit from the shutter that it was hoped they would have done from the theoretical calculations placed before them.

Mr. A. L. STEAVENSON said that, with respect to the results in the experiments which had been given by Mr. Bowlker, he believed if they went to the bottom of the shaft there would be a difference of about 50 per cent. in the water-gauge. Frenchmen were more versed in mathematical theories than were Englishmen, and they had studied this matter, and put it upon a very simple basis. He read the following extract from a paper by Mons. Murgue:—

In theory a depressional ventilator should maintain a constant depression equal to that which it attains when working in a confined space; in reality it is always less, a great part of it being absorbed in the friction and loss of *vis viva* in the air passing through the machine itself. The theory of the equivalent orifice of the mine has already been explained (*see* Proceedings of Mining Institute, Vol. XXXI., page 24), and a similar theory may be applied to the fan itself. The mine and fan may then be represented by two orifices, *a* and *o* :—



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and the volume, depression, and orifices are represented by the formula of air flowing through a thin diaphragm :—

$$V = 0{\cdot}65\, a \sqrt{2\, g\, h}$$
$$V = 0{\cdot}65\, o \sqrt{2\, g\, h_o}$$

The connection between the depression and volume with the equivalent orifice cannot be easily put in language, but may be rendered by diagram. The theoretical depression $\frac{u^2}{g}$ which a Guibal alone is calculated to give, can never be attained, and the initial depression may then be represented by $\frac{k u^2}{g}$ and the actual depression varies according to the following expression :—

$$h = \frac{k u^2}{g} - \frac{V^2}{0{\cdot}65^2\, o^2\, 2\, g}$$

From which formula he deduces the value of o, which is a most important feature in estimating the value of any fan.

This same idea of the loss of pressure, and consequently of volume, was treated by a writer in the *Colliery Guardian* of August 25th, who spoke of the experiments of the Mining Institute, and showed that fans by the same maker had given various results, and the experiments, therefore, were useless; but the fact that they gave different results showed, he (Mr. Steavenson) thought, that the experiments were quite right, because the conditions under which they worked necessarily varied. The writer in the *Guardian* said:—"A good deal has been said and written lately that the present system of calculating the useful effect of fans is misleading, and probably that explains the otherwise mysterious fact that each fan introduced has been proved to have the highest useful effect elsewhere. The report of the North of England Committee, for instance, in its tabulated results, shows some striking differences between fans constructed on the same principle. The Guibal fan shows 40 per cent. useful effect, and another Guibal fan nearly 53 per cent. One Schiele fan shows 46 per cent. useful effect, and another Schiele fan 49 per cent. Any conclusions drawn from contradictory results such as these must, to some extent, be inaccurate." That showed that the writer did not understand what he was writing about.

Mr. D. P. Morison asked if, before entering into the very intricate subject of comparative friction in different systems of centrifugal fans, he might be allowed to make a personal explanation, so far as Mr. Bowlker's remarks affected him; had these remarks not been published in the Transactions he should have merely treated them as good-natured banter to which any equally jocose reply might have been fitting, but as they had gone out to the mining world, invested with

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the authority conferred by the publications of the Institute, he felt compelled to reply to them, in order that his reply might have the same privilege. Any Board of Examination, Mr. Bowlker said, would cashier a candidate who would affirm that the friction due to a Guibal casing was nil (or zero), and that he (Mr. Morison) expected the Guibal fan to subvert the laws of nature. In the first place he would assure Mr. Bowlker that he had every reason to believe that no Board of Examination, on which sat any members cognisant with the principles of the Guibal fan, would disqualify a candidate for stating what was correct; and that he in the second place only expected the Guibal, or any other machine, Mr. Bowlker's included, to carry out the ordinary, though not simple, laws of nature. Leaving this purely personal matter he now proceeded to explain the remarks which called forth Mr. Bowlker's adverse criticism of his qualification for a certificate of competency.

In the first place he stated, more briefly and less clearly than he should have liked, that no friction whatever was due to the Guibal casing as a casing, and this he hoped subsequently to prove. In fact he held that the form of casing, adopted after years of study and practice by M. Guibal, was the only means of not only obviating friction, but of restoring the greater portion of the tangential velocity of the air, which (unlike the radial velocity) was entirely forfeited by every other centrifugal fan, even by that of Mr. Bowlker's own invention.

That there was friction in the passage of the air from the inlet at the centre to the outlet no one would deny, but M. Guibal claims, and the speaker believes justly, to utilise even this friction by his mode of discharge.

Thus at *d*, Plate VII., which is the first point beyond the discharge where depression is exerted, the water-gauge is only 5 millimetres. This gradually increases up to *a*, where it exceeds 20 millimetres, still further increasing at *b* to over 30 millimetres, and reaching its highest tangential energy beyond *b* at the commencement of the evasée circle.

This diagram was copied from one drawn up by the Government officials of Belgium, some twelve years since, from water-gauges placed in the casing at the points indicated, and not made purposely to vindicate any theory, and it would be seen that the figures which are in millimetres show a steadily advancing depression (or the reverse of friction) from the back of the chimney outlet to the channel by which the air alone escaped; and that consequently the casing actually conduced to render the air, should any particles by any chance be foolish enough to take a gratuitous journey round the periphery, more and more frictionless, if he might use such a term.

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The speaker then showed that the tangential energy was restored by the accumulation of depression, which implied want of friction by the casing and by the form of the outlet or evasée chimney, and then continued—To return to Mr. Bowlker's proposal, *i.e.* to derive benefit from a series of similar outlets. What happens? If he puts his number 2 evasée at *a*, his No. 3 at *b*, he loses the depression due to the casing from *a* to *b*, and his No. 1 at *c* is reduced to the same or even worse condition. The air then obtains no potential energy from the tangential force, and becomes, in fact, treated as if in an open fan.

In other words, if three openings suit Mr. Bowlker why not six or even one every foot? Then there was friction, *not due* to the casing but to the friction of the expelled air upon the surrounding atmosphere, inasmuch as no tangential energy could be restored.

Before finally quitting the subject of friction due to the casing, he desired to adduce a practical proof of his assertions, which could be tested by any member of the Institute who was unconvinced and who could spare the time and expense, namely, to make an opening at any part of the casing and find whether more engine power and less air was not the result. The water-gauge would fall nearly thirty per cent., the volume of air in the ratio of the square root, and the steam would have to be greatly increased to keep the same speed of engine with these diminished results.

Having now, he feared, rather appeared to depreciate Mr. Bowlker's system, he must express his opinion that, although wrong in his ideas of practical usefulness to be derived from a number of outlets, he had struck a good chord and one of importance in suggesting a diminution of diameter and an increase of speed. This subject had of late occupied his (Mr. Morison's) attention, and the result of his inquiries had been rather to alter the mode of driving the fan. His friend, Mr. Cockson, of Wigan, had further amplified this by altering the section of the blade so as to obviate the vibration due to the air passing through the outlet; if he succeeded in this he would remedy a defect which he was rather disposed to believe Mr. Bowlker's arrangement would tend to aggravate. He desired to say in conclusion that the two first Guibal fans erected in England in 1865 were at Elswick and Pelton, and they are still working, having cost comparatively nothing beyond the engines which, from overwork and old age, have occasionally given trouble. If the weight on the main bearings could be sensibly reduced and the twisting strain of the crank and connecting rod done away with, the Guibal fan itself would always be found to show the path to many improvements in its application. Experiments on a Guibal fan without blades and air took very nearly the same power as with blades and no air.

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Mr. BOWLKER said, Mr. Morison had exhibited a diagram which was intended to show that the air inside of the Guibal fan produced no friction. He would ask Mr. Morison to say how, with the shutters lowered down to the lowest point and the small aperture that then remained, filled in, 54 horse-power was required, whilst with 40 feet and 45 revolutions less than 59 horse-power was required?

Mr. MORISON—That includes the engine itself.

Mr. BOWLKER—That includes everything. He supposed Mr. Morison would not say that was entirely due to the engine friction, when only about 100 horse-power was spent in ventilation and everything else. Let them suppose that in the fan in question the pressure at the outside showed 760 millimetres, and that the fan was being turned round and discharging air, and that the vacuum was according to the estimate shown on the diagram; then at one point of the circumference the pressure would be 723 millimetres. But supposing the shutter was lowered down and the fan was turned round by itself, the pressure inside the fan would be increased, and it would be not 760 millimetres, but 20 millimetres more, it would be 780 at the periphery. The fact that there was a slight difference in the pressure outside and inside the fan did not show in the least degree that there was no friction. The friction would be as he had stated in the paper, as much as 34 horse-power. The water-gauge was got at the drift doors, and considering that the shaft was short, and that the fan ventilated several miles of underground workings in a thin seam, he hardly thought it likely that 50 per cent. of the water-gauge would be due, as Mr. Steavenson stated, to the depth of the shaft.

Mr. STEAVENSON—Has it been tried at the bottom of the shaft?

Mr. BOWLKER—It has not been tried close to the bottom of the shaft.

Mr. STEAVENSON said, that India-rubber pipes could be lowered down, and the water-gauge obtained, and it would be found to decrease rapidly.

The PRESIDENT said he had seen it done with iron pipes.

Mr. BOWLKER said, some gentlemen thought the cost of the fan would be much in excess of others. He would be glad to let them see whether the cost was greater or less if they were desirous of having fans; and he thought this fan would not only give the highest percentage of useful effect, but would also be the cheapest. The experiments by the Institute experimenter seemed to give from five to ten per cent. better effect than with other fans; and this meant nearly ten to twenty per cent. saving in the steam power required, and was from ten to twenty per cent. in the size of the engine, and in saving of coals, etc.

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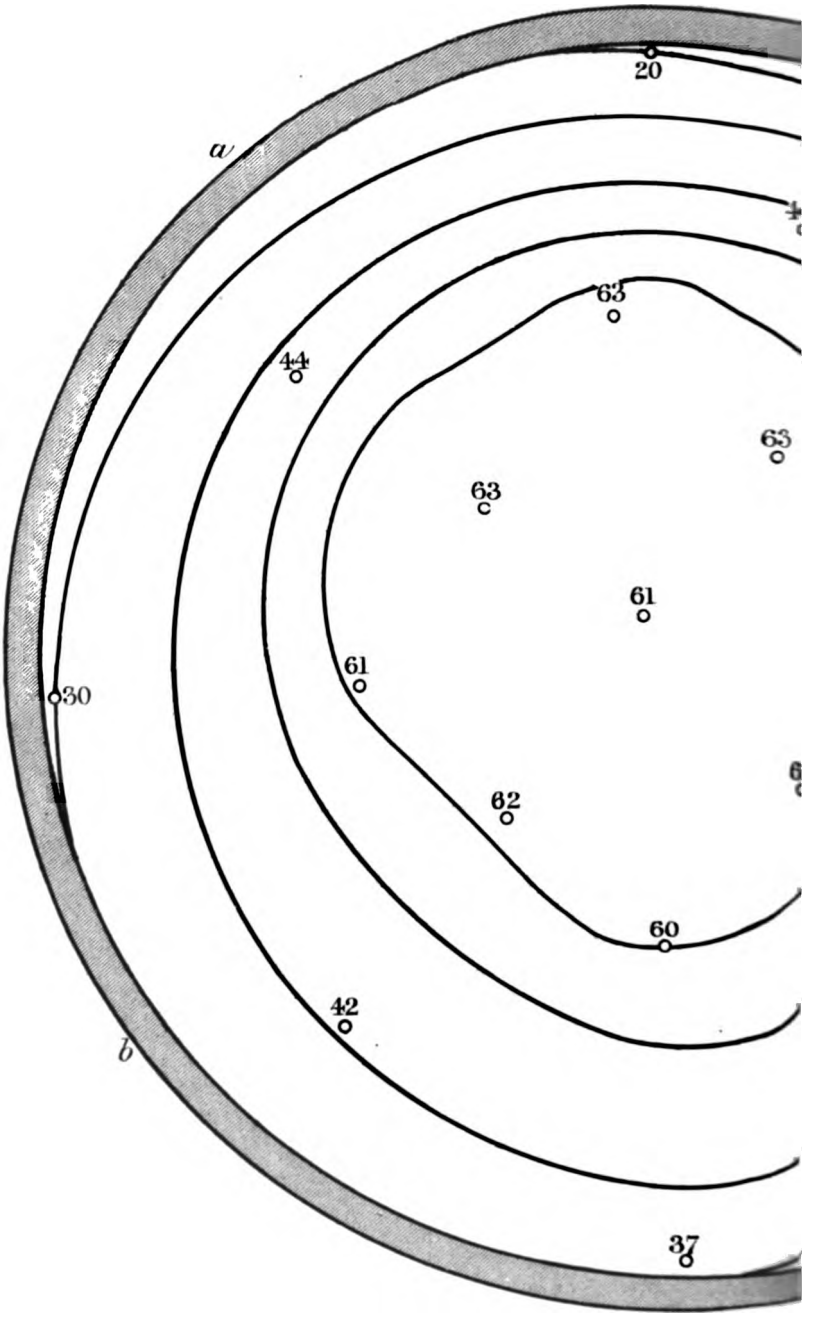

DIAGRAM SHOWING THE DEPRE
OF A GUIBAL VENTILATOR AT WOR

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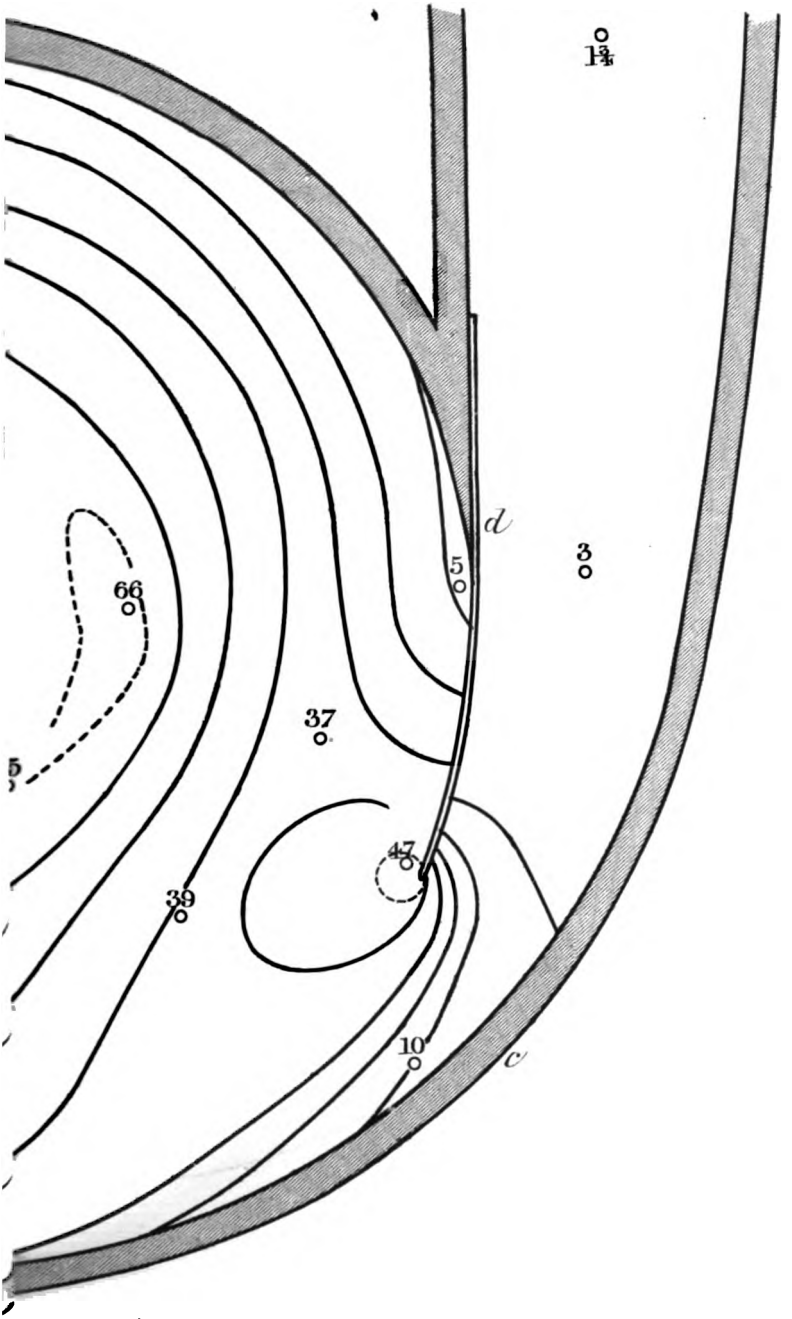
he friction of air in Mechanical Ventilation."



ISSION INSIDE THE CASING

, IN MILLIMETRES OF WATER.

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Mr. W. COCHRANE said, as the experiments recorded by Mr. Daglish yielded only 57 per cent., the ten to fifteen per cent. improvement claimed by the writer was entirely lost. Mr. Bowlker claimed that the fan was still five to ten per cent. better than the Guibal fan, but the figures now before the Institute left no such margin.

Mr. BOWLKER said, that in the Rockingham fan there were special conditions. The fan made the maximum useful effect that could be got out of the Guibal fan. The ordinary working useful effect of the Guibal fan was about 45 per cent.

Mr. MORISON—With the same engine in every case?

Mr. BOWLKER—Yes.

The PRESIDENT said, it seemed to be the general wish of the meeting to adjourn the discussion. The comparison of the useful effect of fans was an important matter. It would be well if the fans could be tried at the same pit and under the same conditions.

The following papers were taken as read:—

"On the Comparative Efficiency of Non-conducting Coverings for Boilers and Steam-pipes" (Second Paper), by Mr. W. J. BIRD.

"On the Mineral Resources of the Rosedale Abbey District," by Mr. CHARLES PARKIN.

The meeting then concluded.

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ON THE COMPARATIVE EFFICIENCY OF NON-CONDUCTING COVERINGS FOR BOILERS AND STEAM PIPES.

(SECOND PAPER.)

By W. J. BIRD.

At the February meeting of the Institute the writer submitted a paper on this subject, and since then his experiments have been further continued. Some new materials have been tested and the results compared according to the method previously adopted. Various thicknesses of the same substances have been tried and thus the economical effect of increasing the thickness of a covering has been determined; and lastly, the saving effected has been calculated in the case of boilers as well as steam pipes, a branch of the subject into which the previous paper did not enter.

The former experiments were made on the following materials—Toope's patent covering, hair felt, Jones's patent British-made silicate cotton, and Burnett's composition. The new substances since tested will now be described.

The silicate cotton tested in the late experiments is manufactured from Cleveland slag, and supplied by Messrs. F. Jones and Co., of London. Its present price is £10 10s. per ton, and as one ton is estimated to cover 800 square feet, 1½ inches thick, the cost per square foot may be taken at 3¼d. Another variety of silicate cotton since tested is that supplied by Messrs. D. H. Dade and Co., of Bermondsey, London, and it has also been tried in the form of a silicate cotton composition. This material is imported from the Continent and differs in appearance and non-conducting properties from that made from Cleveland slag. Its cost is £10 10s. per ton, and as one ton covers 1,067 square feet 1½ inches thick, the cost per square foot is about 2½d.

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However good may be the non-conducting qualities of silicate cotton, it has always suffered from this drawback, that it is of little advantage as regards durability, unless it is encased in an outer covering of sheet-iron, wood, strawboard, or canvas, which of course very materially increases the cost of its application. Consequently it is advisable that it should be applied in the form of a cement or composition, which shall be self-adherent to the surface to be covered. The difficulty is to effect this improvement without destroying the porosity of the cotton and impairing its non-conducting value. Jones's silicate cotton cement, of which the test results were given in the former paper, adhered well and was durable, but its efficiency as a non-conductor was very low. Dade's silicate cotton composition is a recent patent, which is also self-adherent and durable and possesses a high non-conducting value. It is a plastic material whose main constituent is silicate cotton bound together with a cementing substance. Its price is £7 10s. per ton, and as one ton is estimated to cover 280 square feet 1½ inches thick the cost amounts to 6¾d. per square foot.

This composition was tested at the thicknesses of 1 inch, 1½ inch, and 2 inches. It adheres well to the surface, and possesses a very high degree of durability owing to its being composed entirely of mineral substances. It also possesses a certain amount of elasticity which enables it to remain closely adherent to the surface, notwithstanding the expansion and contraction caused by repeated heating and cooling. When dry it forms an extremely light covering, the weight being only 1½ lbs. per square foot, 1½ inches thick.

A sample of the material manufactured by the Eagle Non-conducting Cement Company has been tested. This cement adheres very well, sets quickly, and makes a very hard and compact covering. It contains a considerable proportion of fibrous material and hair. Its price is £3 10s. per ton, and as one ton covers 213 square feet, 1½ inches thick, the cost per square foot may be reckoned at 4d. The observations show that it possesses a moderate non-conducting value.

All the observations were made on the large steam-pipe 10⅝ inches external diameter, mentioned in the previous paper. They were conducted in the same manner as there described and the heat loss determined in a similar way, so that it will be unnecessary to again detail the process of deduction.

The following table shows the temperatures observed, and the consequent heat loss, and percentage of efficiency. Most of the figures quoted in the former paper are also included in this and the following tables :—

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TABLE I.

Name of Material.	Thickness.	Temperature of,			Heat Loss, Units per Hour.				Efficiency.
					Per sq. foot.		Per ft. length.		
	Ins.	Bare Pipe.	Cov. Pipe.	Air.	Bare Pipe.	Cov. Pipe.	Bare Pipe.	Cov. Pipe.	Per cent.
Toope's patent covering ...	¾	251	111	67	357·7	66·4	990·8	208·5	78·9
Do. do. ...	1½	251	96	67	357·7	41·3	990·8	147·0	85·2
Hair felt	¾	251	142	68	357·7	118·5	990·8	372·0	62·3
Do.	1½	251	118	67	357·7	75·3	990·8	268·1	73·9
Jones' silicate cotton	1½	251	126	67	357·7	89·9	990·8	320·0	67·7
Do. do. ...	3	251	107	67	357·7	57·0	990·8	247·4	76·0
Dade's do. ...	1½	248	103	63	356·2	57·0	986·5	203·0	79·4
Do. do. composition	1	237	117	74	308·4	63·2	854·2	208·0	75·6
Do. do. do.	1½	244	72	55	359·1	21·4	994·7	76·0	92·4
Do. do. do.	2	244	63	54	360·8	10·4	999·5	39 8	96·1
Eagle non-conducting cement .	1½	246	128	61	354·5	102·2	981·5	363·9	62·9
Burnett's composition ...	1½	251	124	67	357·7	85·7	990 8	305·1	69·2
Do. do. ...	3	251	102	63	357·7	52·2	990·8	226·5	78·1

From this table may be observed the increase of efficiency obtained by increasing the thickness of covering. To double the thickness means of course making the cost of material a little more than double, while the non-conducting efficiency is increased only to a small extent. The following table compares the efficiencies at different thicknesses as far as the observations go:—

TABLE II.

Material.	Thickness in Inches.				
	¾	1	1½	2	3
	Percentage of Efficiency.				
Toope's patent covering	78·9	...	85·2	...	...
Hair felt	62·3	...	73·9	...	...
Jones's silicate cotton	...	...	67·7	...	76·0
Dade's silicate cotton composition	...	75·6	92·4	96·1	...
Burnett's composition	...	...	69·2	...	78·1

From the average of these results it appears that if the thickness of the covering is doubled the non-conducting efficiency is increased only in the ratio of 1 to 1·16, or 16 per cent. Remembering at the same time that the cost of covering is more than doubled, any increase of efficiency thus

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obtained is at a disproportionate expense. Hence it may be concluded that the most essential requisite in a non-conducting covering is that it should possess a high non-conducting efficiency with a moderate thickness employed.

For the purpose of further comparison it may be as well to select one certain thickness of each material, viz., ¾ inch for Toope's patent covering and hair felt, and 1½ inches for all the other substances tested.

It will now be advisable to state the absolute saving effected by the use of each covering in the case of steam-pipes and boilers. Firstly, supposing the range of steam-pipes to be 1,000 feet in length from the boilers to the engine, a state of things not infrequent in colliery practice, and the external diameter of the steam-pipe 10⅝ inches as before, and assuming that the heat loss on the 1,000 feet range to be simply 1,000 times that of one foot length; this assumption would be quite correct for pipes in a horizontal position, although the loss on a vertical column would be in a slightly less proportion. As 69,674 heat units per hour are equal to one nominal horse-power, the heat loss can be stated in these terms. The cost of each material in coating the 1,000 feet length is also shown, and thus the cost per horse-power saved is stated. The annual saving of fuel is estimated, assuming the engine to be continuously worked, at a consumption of coal of 2 cwts. per nominal horse-power per 24 hours. The value of the fuel is taken at 4s. per ton, each nominal horse-power thus costing £7 6s. per annum.

TABLE III.

HEAT LOSS FROM 1,000 FEET OF PIPE, 10⅝ IN. EXTERNAL DIAMETER.

MATERIAL.	Thickness.	NOMINAL H.P.			COST OF MATERIAL.		Fuel Saved per Annum.
		Loss.		Saving.	Total.	Per Nominal Horse-power Saved.	
		Bare Pipe.	Covered Pipe.				
	In.				£ s. d.	£ s. d.	£ s. d.
Toope's patent covering	¾	14·22	2·99	11·23	137 9 11	12 15 9	81 19 7
Hair felt	¾	14·22	5·34	8·88	45 16 3	5 3 2	64 16 6
Jones' silicate cotton ...	1½	14·22	4·59	9·63	41 3 7	4 5 6	70 6 0
Dade's silicate cotton ...	1½	14·16	2·91	11·25	31 3 8	2 15 5	82 2 6
Dade's silicate cotton composition ...	1½	14·23	1·09	13·14	84 17 1	6 9 2	95 18 5
Eagle cement	1½	14·09	5·22	8·87	51 12 1	5 16 4	64 15 0
Burnett's composition...	1½	14·22	4·38	9·84	42 18 0	4 7 2	71 16 8

Comparing boilers with steam-pipes, it is evident that if the thickness of covering, the temperature of the bare surface, and the temperature of

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the air, remain the same as in the case of the steam-pipes, then the outside temperature of the covering will also be unaltered. But still, under these similar conditions the same covering will give a different percentage of efficiency on a boiler than on a steam-pipe.

The loss per square foot per hour from radiation remains the same in both cases, since the radiation loss depends not at all on the size or shape of a body, but solely on its temperature and that of the surrounding medium. The loss from contact of air however is different, since it depends on the shape and size of the heated body. The air contact loss per square foot diminishes as the diameter of the body increases. Thus the total heat loss per square foot per hour is less on a boiler than on a steam-pipe, under equal conditions, and it is also less on a large steam-pipe than on a small one.

In these calculations the boiler taken is one of 35 nominal horse-power of the Lancashire variety, 28 feet long and 7 feet 6 inches diameter. It is embedded in masonry, only 1 foot 8⅓ inches of the vertical diameter remaining exposed. It is the usual practice in boilers to leave the furnace end uncovered, and consequently the area to which the covering is limited is in this case 225 square feet. With a covering ¾ inch thick the cooling surface is 230 square feet, and 235 square feet where the covering is 1½ inches thick.

Having ascertained the heat losses per square foot on the bare and covered boiler, and multiplied by the extent of cooling surface, the total heat loss in both cases is ascertained, from which the percentage of efficiency is calculated. It will be observed that this efficiency is higher than it was in the case of the steam-pipes. The remainder of this table is deduced in the same manner as the previous one, and thus the effect of the different coverings on a boiler can be compared.

TABLE IV.

Material.	Thickness.	Heat Loss, Units per Sq. Ft. per Hour.		Efficiency.	Nom. H.P. Loss.		Nom. H.P. Saving.	Cost of Material. Total.	Cost of Material. Per Nominal H.P. Saved.	Fuel Saved per Annum.
		Bare.	Covered.		Bare.	Covered.				
	In.			%				£ s. d.	£ s. d.	£ s. d.
Toope's patent covering	½	342·4	64·1	80·9	1·11	0·21	0·90	10 1 3	11 3 7	6 11 5
Hair felt	½	342·4	114·2	65·9	1·11	0·38	0·73	3 7 1	4 11 11	5 6 7
Jones' silicate cotton ...	1½	342·4	87·1	73·4	1·11	0·29	0·82	3 3 8	3 17 8	5 19 8
Dade's silicate cotton ...	1½	340·8	55·1	83·1	1·10	0·19	0·91	2 6 2	2 10 9	6 12 10
Dade's S.C. composition	1½	343·4	20·6	93·7	1·11	0·07	1·04	6 5 11	6 1 3	7 11 10
Eagle cement	1½	339·0	98·6	69·6	1·09	0·33	0·76	3 17 2	5 1 7	5 11 0
Burnett's composition .	1½	342·4	83·0	74·7	1·11	0·28	0·83	3 3 7	3 16 8	6 1 2

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Having now determined the heat losses both for steam-pipes and boilers, it will be interesting to see how much of the initial nominal horse-power of the boiler remains when the steam arrives at the engine.

Taking the case of two boilers, each 35 nominal horse-power, of the same dimensions as before, communicating with the engine by a range of steam-pipes 1,000 feet long and $10\frac{5}{8}$ inches external diameter. The initial nominal horse-power at the boiler is then 70, and the losses of the two boilers will be just twice that of a single boiler, which is shown in the preceding table. In the table the percentage of efficiency of each covering for both boilers and steam-pipes is placed in the first two columns for the purpose of ready comparison.

TABLE V.

Material.	Thickness.	Efficiency per cent.		Nominal Horse-Power.							
				Loss on Boilers.		Remains.		Loss on Steam Pipes.		At Engine.	
		On Boiler.	On Steam Pipe.	Bare.	Covered.	Bare.	Covered.	Bare.	Covered.	Bare.	Covered.
	In.										
Toope's patent covering	$\frac{3}{4}$	80·9	78·9	2·22	0·42	67·78	69·58	14·22	2·99	53·56	66·59
Hair felt	$\frac{3}{4}$	65·9	62·3	2·22	0·76	67·78	69·24	14·22	5·34	53·56	63·90
Jones' silicate cotton	$1\frac{1}{2}$	73·4	67·7	2·22	0·58	67·78	69·42	14·22	4·59	53 56	64·83
Dade's silicate cotton	$1\frac{1}{2}$	83·1	79·4	2·20	0 38	67·80	69 62	14·16	2·91	53·64	66·71
Dade's silicate cotton composition	$1\frac{1}{2}$	93·7	92·4	2·22	0·14	67·78	69 86	14·23	1·09	53·55	68·77
Eagle cement ...	$1\frac{1}{2}$	69·6	62·9	2·18	0·66	67·82	69·34	14·09	5·22	53·73	64·12
Burnett's composition	$1\frac{1}{2}$	74·7	69·2	2·22	0·56	67·78	69·44	14·22	4 38	53·56	65·06

The writer will next proceed to consider the question of durability. It may be asserted that all the materials examined possess this quality, except the silicate cottons and hair felt, which were applied in a loose state and tied on. An outer covering of sheet-iron, wood, strawboard, or canvas is necessary to give them durability, and the most effective would be the sheet-iron, which would also be the most expensive.

The chief deteriorating agencies to which non-conducting coverings are exposed are heat and damp. Materials containing vegetable fibre and hair are most liable to damage from heat. Burnett's composition and the Eagle cement will thus deteriorate and become loose, to some extent, in course of time. Toope's covering, though largely composed of organic

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matter, is protected by an inside skin of asbestos, which makes it durable against heat. The silicate cotton composition, being entirely mineral, will resist heat best.

As against damp, the silicate cotton composition, the Eagle cement, and Burnett's composition are all very durable. Toope's covering is very liable to damage from this cause, and requires a waterproof covering to make it durable in wet situations.

Having now gone through the main points of inquiry, a summary is given of their results by comparing the substances in their order of merit as regards:—

1.—Efficiency.
2.—Saving of fuel.
3.—Absolute cost of material.
4.—Cost relative to horse-power saved.

1.—*Efficiency.*—The order of merit is: 1, Dade's silicate cotton composition; 2, Dade's silicate cotton; 3, Toope's covering; 4, Burnett's composition; 5, Jones' silicate cotton; 6, Eagle cement; 7, Hair felt.

2.—*Saving of fuel.*—The coverings have the same order of merit.

3.—*Absolute cost of material.*—1, Dade's silicate cotton; 2, Hair felt; 3, Burnett's composition; 4, Eagle cement; 5, Jones' silicate cotton; 6, Dade's silicate cotton composition; 7, Toope's covering.

4.—*Relative cost.*—1, Dade's silicate cotton; 2, Burnett's composition; 3, Hair felt; 4, Jones' silicate cotton; 5, Eagle cement; 6, Dade's silicate cotton composition; 7, Toope's covering.

In conclusion, the writer would remark that this list of non-conducting coverings by no means includes all substances in the market. However, the experiments have been made on various materials in extensive use, which are, no doubt, as good as any at present before the public.

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ON THE MINERAL RESOURCES OF THE ROSEDALE ABBEY DISTRICT.

By CHARLES PARKIN.

With the exception of the ironstone, including the famous magnetic deposit, the Rosedale Abbey district has received very little attention, but although the mineral described may be considered of the first importance, the extensive beds of limestone and freestone, together with the presence of alum shale, jet, cement stones, road metal (inferior limestone), lead, clays, coal, and valuable peat beds, render the neighbourhood worthy of more notice than it has attracted hitherto. The supply of ironstone and limestone from this quarter into the Cleveland iron and steel trade will, no doubt, in the future be considerable. It is intended in this paper to remark on each of the minerals separately.

1.—IRONSTONE.—DESCRIPTION OF PAST OPERATIONS.

The geological formation of the ironstone has been repeatedly described, and it is therefore unnecessary to say more on this part of the subject, except to refer those who wish for further details to the papers read before the members of this Institute by Mr. John Marley in June, 1857,* by Mr. Joseph Bewick in December, 1857,† by Mr. N. Wood in February, 1859,‡ and by Mr. John Marley again in August, 1870.‖

The oolitic rocks of England extend from Redcar, near the mouth of the Tees, to Filey Bay, on the East Coast, a distance of nearly 50 miles, and reach westward to Stokesley, Northallerton, Thirsk, and Easingwold, and form the surface strata of the Rosedale Abbey district.

According to Dugdale's Monasticon, Vol. I., page 507, an inspeximus dated at York the 26th February, 1328, the 2nd of Edward III., recites a grant made on the 16th of August, 1209, by Robert de Stuteville, of a meadow in Rosedale, to the nuns of that place *near to his forge.* This circumstance, and the presence of numerous heaps of slag and remains of ancient works, having the appearance of hearths where charcoal has been burnt, afford ample proof that iron was manufactured here early in the thirteenth century.

In the year 1859, the late Mr. George Leeman and Partners obtained a lease of the extensive royalty of West Rosedale and Spaunton, containing about 8,000 acres, for a period of sixty years, Plate VIII. and the portion coloured green, belonging to Henry Darley, Esq.; and in the same year the

* Vol. V., page 165. † Vol. VI., page 15. ‡ Vol. VII., page 85. ‖ Vol. XIX., page 193.

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North-Eastern Railway Company applied for and obtained an Act of Parliament empowering them to construct a branch line from Battersby Junction to the West Rosedale Mines for the transit of the ironstone, which was chiefly sent to the Ferryhill Iron Works. Five years afterwards, Mr. Leeman and his Partners became associated with the late Mr. James Morrison of Newcastle-upon-Tyne, under the style of "The Rosedale and Ferryhill Iron Co.," and having purchased the Rosedale Abbey Estate, they opened up the ironstone on the east side of the dale, and the Rosedale Branch Railway was extended for the carriage of it, Plate IX. In 1874, the Company further increased their output by sinking Sherriff's Pit on the west side to the north of the magnetic workings. In 1879 the mines were stopped owing to the depression in trade; but in 1880 Sherriff's Pit and West Rosedale Mines were bought by the West Rosedale Ironstone Company, Limited, and a small output of magnetic ironstone is now being vended. Messrs. Navery and Company opened the Farndale Mines in 1873 (adjoining the West Rosedale Royalty), from which a considerable quantity of ironstone has been quarried, but the mines are closed at present.

The following statistics, kindly supplied by Robert Hunt, Esq., F.R.S., of the Mining Record Office, show the output of ironstone from the Rosedale Mines since their commencement in 1859, up to the end of last year :—

Date.	Tons.	Where from, etc.
1861	79,786	Magnetic.
1862	219,123	Do.
1863	224,889	Do.
1864	297,579	Do.
1865	250,000	Do.
1866	233,382	Do. and East Mines.
1867	178,227	Do. Do.
1868	210,082	Do. Do.
1869	269,595	Do. Do.
1870	317,060	Do. Do.
1871	314,394	Do. Do.
1872	450,350	Do. Do.
1873	560,668	Do. Do.
1874	473,140	Do. Do.
1875	383,914	Do. Do.*
1876	383,828	Do. Do.*
1877	347,486	Do. Do.
1878	234,150	Do. Do.
1879	25,593	Do. Do.†
1880	Nil.	Mines closed.
1881	6,079	Sherriff's Pit reopened.
Total	5,459,325	

* And Sherriff's Pit. † Mines closed in March.

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This output, with the exception of about 32,000 tons from Sherriff's pit, was nearly all calcined at Rosedale, kilns for that purpose being erected both at the east and west mines.

PRESENT AND FUTURE DEVELOPMENT.

The magnetic ironstone, so far as present discoveries are concerned, will soon be all worked out, so, in the absence of new discoveries, the future working must be from the regular seam or seams. The seam now worked at the mines in this district is what is termed in Mr. Marley's paper the top seam of the lias formation, and overlies the magnetic deposits; the average thickness workable may be taken at 6 feet, although it varies very much at the different points opened up. The beds dip south about 1 in 22, and the specific gravity of this ironstone is about 2·35, or equal to 15 cubic feet per ton. As the seam is followed to the dip it takes off materially both in quality and thickness; this is particularly illustrated at Sherriff's pit, where, at the drift mouth, the seam is 8 feet thick, but at the extremity of this drift, about 460 yards in from the outcrop, it is only 3 feet 8 inches thick, and the percentage of the stone only 29·50 per cent. The gradual falling off will be seen by the figures below :—

	Seam.	Iron.
At entrance to drift	8′ 0″	35·44
„ 3rd bord to left		33·80
„ 12th „ right		32·60
„ pit bottom (42 fms. deep)		29·95
„ end of drift	3 8	29·50
Average of the five places		32·26

The overlying strata is principally sandstone or freestone, through which the water rapidly passes, causing an excess of moisture in the ironstone during wet weather which is somewhat detrimental to the sale of it. This drawback, however, is much less in the summer months, as the following assays of train loads sampled as received at the furnaces prove:—

	Iron in wet state.	Moisture.	Dried at 212° F.
Average of three winter months ...	29·53	14·08	34·37
„ three summer „ ...	33·20	10·42	37·07

The output per man per shift of eight hours is less here than in Cleveland, owing, to some extent, no doubt, to the beddy nature of the seam

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which militates against successful blasting. The Cleveland men average about 5¼ tons per shift, whilst the Rosedale miner only averages about 3¼ tons per shift; consequently, it is obvious that the latter must be paid an extra tonnage rate in order to make wages equal to the Cleveland men. The present price is 1s. 2d. per ton at Rosedale, with extra yard money and consideration paid for working the magnetic ironstone deposit. The cost per ton for timbering runs from 4d. to 6d., and the royalty paid is 4d. per ton for ironstone under 40 per cent., and 6d. per ton for that yielding over 40 per cent.

Now comes the all-important question as to what may be safely assumed the average percentage of the Rosedale ironstone as supplied to the market, and although the writer has no hesitation in stating that samples taken in certain districts of any of these mines will yield up to 35 per cent. of iron, yet he is bound to add that in other places the yield will not exceed 20 or 25 per cent. On Plate X. will be found the percentage of ten working places in the Rosedale East Mines, taken at points which embrace the whole area of the workings. The average of these eight places give a seam of 6 feet 6 inches thick, and a yield of 29·35 per cent. of iron. The seam has been analysed also midway between Sherriff's pit and the West Mines on the west side of Rosedale, and the result arrived at as under may be considered as a fair average of the district :—

	Seam. Ft.	Ins.	Iron.
Average of ten working places—East Mines ...	6	6	29·35
„ five „ Sherriff's Pit ...	5	10	32·25
Midway between West Mines and „ ...	6	0	24·50
Average of Rosedale district	6	1	28·70

It must be remembered that if great care is taken, and the operations confined to certain districts where the stone yields well, it is possible to supply ironstone of a higher percentage than the average here given, and, as it is, the Rosedale stone compares fairly with the average of the Cleveland mines. It may not be out of place to give a few complete analyses of some of the mines in Cleveland, Lincolnshire, and Rosedale, showing each element contained in the stone. The writer would not wish it to be inferred that the following results are an average of each mine, but the analyses given are from *bonâ fide* samples taken from each place :—

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Element—Raw Stone.	Rosedale District.				Cleveland District.								Lincolnshire District.		
	West Rosedale Magnetic.	Sherriff's Pit.	East Rosedale.	Farndale.	Kirk-leatham.	Upleatham.	Brotton.	Crags Hall.	Lofthouse.	Stanghow.	Slapewath.	Whitecliff.	Allesbury.	Ellesworth.	Mid-Lincoln.
Peroxide of iron	42·14	17·92	26·57	49·57	21·85	9·21	6·11	2·14	3·07	1·00	2·62	2·79	5·35	14·85	46·07
Protoxide of do.	14·33	28·67	18·19	...	23·40	33·10	35·21	36·64	35·35	34·64	30·72	33·10	24·42	35·16	trace
Peroxide of manganese	...	...	...	·63	...	...	...	...	...	...	...	...	...	...	...
Alumina	8·55	8·52	9·84	2·02	11·04	11·92	12·71	13·53	11·70	12·43	10·83	13·53	18·05	8·40	8·15
Lime	2·52	4·97	6·24	3·70	5·29	5·37	5·65	5·54	4·62	5·93	5·06	3·75	12·46	4·59	4·67
Silica	16·80	10·80	18·55	11·83	9·20	11·90	12·35	14·10	15·75	13·70	18·85	18·70	3·22	5·98	22·20
Phosphoric acid	1·63	2·00	1·43	·48	2·26	1·53	1·39	1·02	1·10	1·69	1·37	·70	2·99	1·40	1·98
Sulphur	trace	·10	·03	·52	trace	·38	·70	trace	·28	·37	3·88	trace	1·40	·50	trace
Magnesia	1·15	3·10	2·91	3·18	2·56	3·42	1·65	3·56	2·79	3·33	3·42	4·33	10·90	2·28	·61
Moisture, etc....	12·50	23·50	16·40	25·03	24·15	22·80	24·13	22·70	25·40	26·79	23·15	22·70	20·65	26·65	17·00
Metallic iron	40·65	34·85	32·75	34·07	33·50	32·20	30·00	30·00	29·65	28·20	27·55	27·35	24·25	37·75	32·25

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Midway between West Mines and Sherriff's pit, under the sub-soil, is about 30 feet of good freestone, followed by about 70 feet of sandstone beds intermixed with blue shale; under this is the seam of ironstone locally known as "the top seam of the district," which is separated from the seam now being worked at the mines by about three feet of soft blue shale, with coal pipes, and one foot of dogger band. The "top seam" at this point yields 29 per cent. of iron, but is very siliceous, and contains many pure blocks of freestone, enveloped in a thin ironstone shell; it is about eight feet thick here, whilst the seam below is only six feet thick, and very poor, yielding only 20 per cent. It is also very sandy, consisting of round blocks of light blue ironstone, very similar to the Cleveland stone, incrusted in brown sandstone. It is worthy of notice that where the "top" seam is rich, the bottom one is correspondingly poor, for instance, near Sheriff's pit, the "bottom" or working seam yields 32 per cent., whilst the "top" seam yields only 24 per cent.

The railway carriage to the Cleveland and other furnaces is a heavy item, the current rates paid being as follows :—

District.	Ironworks.	Rate per Ton.	Remarks.
		s. d.	
Middlesbro'	Tees	1 7½	These rates are from
South Bank	Clay Lane ...	1 8½	Sherriff's pit, the rates
Stockton	Tees Bridge ...	1 9½	from the other mines
North Yorkshire ...	Glaisdale	1 9½	ranging from 1d. to 2d.
Redcar	Redcar	1 10½	per ton more.
Whitby	Grosmont ..	1 11½	5 per cent. discount
Durham	Witton Park ...	2 10	is allowed on payment
Ditto	Consett	3 7½	of carriage account.

These are high rates when compared with the carriage from the Cleveland Mines to the furnaces, but whether it would answer to erect furnaces at Rosedale is questionable; the ironstone and limestone would be close at hand, but on the other hand the coal and coke would have to be got from the Durham district, and there would be the carriage of the pig iron back to Middlesbro'. A rough estimate of the cost of making one ton of pig iron at Rosedale, on a production of 800 tons per week, would be about as follows:—

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			s.	d.	s.	d.
3½ tons ironstone	... ...	at	3	0	10	6
1½ „ coke	... ...	at	14	0	15	9
¾ „ limestone	... ...	at	2	0	1	4
¼ „ coal	... ...	at	5	6	1	4½
Works, repairs, and stores	... ...				1	4
Management, etc.	... ...				1	0
Labour (say)	... ...				3	3½
Cost per ton at the ironworks	... ...				£1	14 7

The railway carriage of a ton of pig iron to Middlesbro' would be about 3s., and to make 800 tons of pig iron per week would require 2,800 tons of ironstone per week.

In addition to the ironstone seams mentioned, the Cleveland Main Seam crops out at several places in the dale; at one point a sample was analysed by Messrs. Stead and Pattinson, of Middlesbro', giving the following result:—

	Per Cent.	Per Cent.
Iron	25·20	11·00 oxygen.
Silica	30·00	
Loss by calcination	21·58	76·70
Iron in calcined state	32·10	87·70

The seam is thin, ranging from 1 to 2 feet thick only, at the various outcrops visible.

2.—LIMESTONE.

The limestone under observation is that which is worked at Pickering, Cropton, and district lying south-west of Rosedale. Plate XI., Fig. 1, is a section taken from one of the largest of the Pickering quarries, where the limestone is wrought and sent to the Grosmont Iron Works, and worked here, and elsewhere in the district, for agricultural purposes. The working beds are laid 8 or 9 feet from the surface, about 45 feet thick, divided into blocks 3 feet, 2 feet 6 inches, and 2 feet in thickness, and in colour light grey and blue black; under this is 13 feet of hard limestone of poor quality, locally termed "road metal," and used for repairing roads and building purposes; below which is 18 inches of cockle-shell post, overlying 17 feet of yellow sandstone. This sandstone bed in other localities is found to be loose, dry sand. Under this again is 2 feet of very hard blue flinty post overlying another bed of grey limestone, the thickness of which is not visible. Analyses of the beds wrought here give not more than 84 per cent. of carbonate of lime, but at the Deepdale quarries, situated between Hutton-le-Hole and Appleton Common, it appears to improve in quality. Here the beds, of similar size and colour to those at Pickering,

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yield 93 per cent. of carbonate of lime or 9 per cent. more than the Pickering stone. The Pickering and Kirbymoorside railway passes in close proximity to the south end of the dale, and the West Rosedale branch railway is situated about four miles from the north end quarries. The beds visible on each side of the vale of Deepdale are about 150 feet in thickness, intermixed with sandstone. Samples taken from six of the Deepdale beds, assayed by Mr. Alfred Procter, Middlesbro', yield as follows:—

	1.	2.	3.	4.	5.	6.
Sand, clay, etc.	9·00	6·40	5·10	3·00	4·10	6·60
Carbonate of lime ...	89·40	92 40	94·40	96·20	94·50	92 50
Carbonate of magnesia ...	·50	·75	·75	·20	·70	·50
Moisture	1·10	·45	·45	·60	·70	·40
	100·00	100·00	100·70	100·00	100·00	100·00

Nos. 1, 2, 3, and 4, follow successively in beds 6 feet thick; No. 5 is a sample of 20 feet of limestone, and No. 6 of 10 feet.

The limestone now used at the Cleveland furnaces contains from 96 to 97 per cent. of carbonate of lime.

The railway carriage on this limestone to the Middlesbro' Iron Works from Pickering would be about 2s. 6d. per ton, and from Deepdale about 2s. 10d. per ton.

3.—ROAD METAL (Inferior Limestone).

The material used for repairing roads is an inferior hard flinty limestone, the extensive beds in this district present the opportunity of carrying on a successful trade in road metal, provided the necessary but small extension of railway accommodation was made. The only point to which the writer would draw particular attention is the Spindlethorne Hill beds, situated about a mile west of Rosedale bank top, on the Spaunton Moor, where the stone has been largely quarried for highway purposes. These beds are quite separate from the general limestone beds of the district which have just been under notice, and are laid above the freestone and ironstone of Rosedale. Plate XI., Fig. 2, is a section of one of the quarries; first there is about 5 feet of isolated boulders of the stone, of various shapes, but principally oblong, through which may be found round water holes of different dimensions; these blocks are embedded in brown soft sand; below these boulders is a compact bed of the stone about 4 feet thick; under this again is 3 or 4 inches of fossilized post overlying a bed of light blue shale. The beds crop out in Loskey Beck on the Spaunton Moor, from the bed of which the writer took the following observations, which will show the strata surrounding the Spindlethorne beds.

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The water in the Deepdale beck (as well as others in the immediate neighbourhood) disappears below the surface during dry weather, in some places leaving the bed of the river perfectly dry for two or three miles and flowing out again at some distance further on. The writer presumes this is caused by swallow holes, which are of common occurrence in the limestone formation in various parts of Yorkshire and elsewhere. The discussion on Mr. J. B. Simpson's paper "On Natural Pits in the Coal Measures of Belgium," read before the members of this Institute in December, 1873, (Vol. XXIII., page 74) deals with this phenomenon.

COMMENCING AT FOOTPATH TO DARLEY LODGE.

	Feet.
1.—Freestone	5
2.—Shale, light sandy	3
3.—Freestone, soft brown	6
4.—Freestone, hard brown	2
5.—Shale, soft, sandy, yellow	6
6.—Shale, light blue with 3 in. coal pipe	4*
7.—Flinty limestone, compact	4*
8.—Sandstone soft	1*
9.—Flinty limestone boulders enveloped in brown sand	4*
10.—Sandstone, alternate beds of white and yellow	20
11.—Sandstone, full of small round water holes	2
12.—Shale, soft blue	2
13.—Sandstone, very light yellow	3
14.—Shale, grey and blue soft	6
15.—Dogger band, hard red	3
16.—Shale, strong blue	4
17.—Sandstone and loose sand	4
18.—Blue shale and sand	16
19.—Hard flinty post	2
20.—Shale, soft blue	12
Total	109

Left off at Loskey Bridge.

* See Section of Spindlethorne Quarries, Plate XI.

Analyses of this stone give:—

Iron	7·05
Silica	2·15
Carbonate of lime	78·05

4.—FREESTONE.

The freestone and flagstone beds are laid about 70 feet above the "top seam" of ironstone; there are several good quarries of freestone in the district presenting a face of from 20 to 30 feet thick, and the stone is found very suitable for building purposes; the flagstone from the Rosedale quarries is exceptionally good.

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5.—CEMENT STONES.

The cement stones occur in round balls; the band containing them is immediately above the top ironstone seam and is about 2 feet thick. Up to the present time they have not been worked here.

6.—ALUM SHALE, JET, AND CLAYS.

The writer having already read a paper on the jet and alum shale before the members of this Institute (see Transactions Vol. XXXI., page 51) it is unnecessary to describe these well-known minerals, both of which are found here in fully-developed beds and deposits. Above the cement stone band is a bed of good clay suitable for brick making purposes.

Owing to a change in the manufacture of alum, Al $(H_4 N)$ (SO_4) 2, has of late years been substituted for that made from the common alum shale or alum chist.

7.—COAL AND PEAT.

Some seams of inferior coal have been formerly worked on the Rosedale Moors, D.D. Plate IX., the deepest shaft not exceeding 30 yards. The seams are in thickness from 1 inch up to 20 inches, those which have been worked varying from 12 to 20 inches. Before the branch railway was made to Rosedale a considerable trade was carried on both for household purposes and for burning limestone. The coal is of a shaley nature and burns to a white ash. On the moorland surrounding Rosedale there are extensive peat beds, ranging from 1 up to 10 feet thick, and lying usually on a loose white sand foundation. On the West Moor, at a place known as Jewell Mere, there is a peat bed covering an area of about 100 acres, a considerable portion of which averages about 6 feet in thickness, and the West Rosedale railway passes close to the ground, affording every facility for conveying away the peat. That these beds might be utilized both for steam and other purposes is indisputable, and if cut and dried by machinery, similar to the plan adopted with the Dartmoor peat in Devonshire, the peat could be sold to the district at a cheaper rate than the coal is supplied at now. The writer visited a copper mine in Wales some time ago where peat was cut close to the mine for engine purposes; it was prepared for about 6s. per ton, the calorific value of which was about 70 per cent. of coal by weight. The only alteration which it had been found necessary to make at this mine in using peat in lieu of coal was that the grate surface and heating surface of the engine boiler had to be proportioned for the heating power of peat, the surfaces being in proportion, nearly inversely, as 70 to 100.

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8.—LEAD.

The writer would remark on this subject with some degree of reserve at present, as his investigations in the matter are as yet incomplete. Lead ore has been found in different situations of this district, but whether the ore exists in sufficient quantity to pay for working remains to be proved: at some future meeting it may be possible to throw further light on the subject.

The writer is indebted to Mr. John Campion, of West Rosedale, for valuable assistance in preparing this paper.

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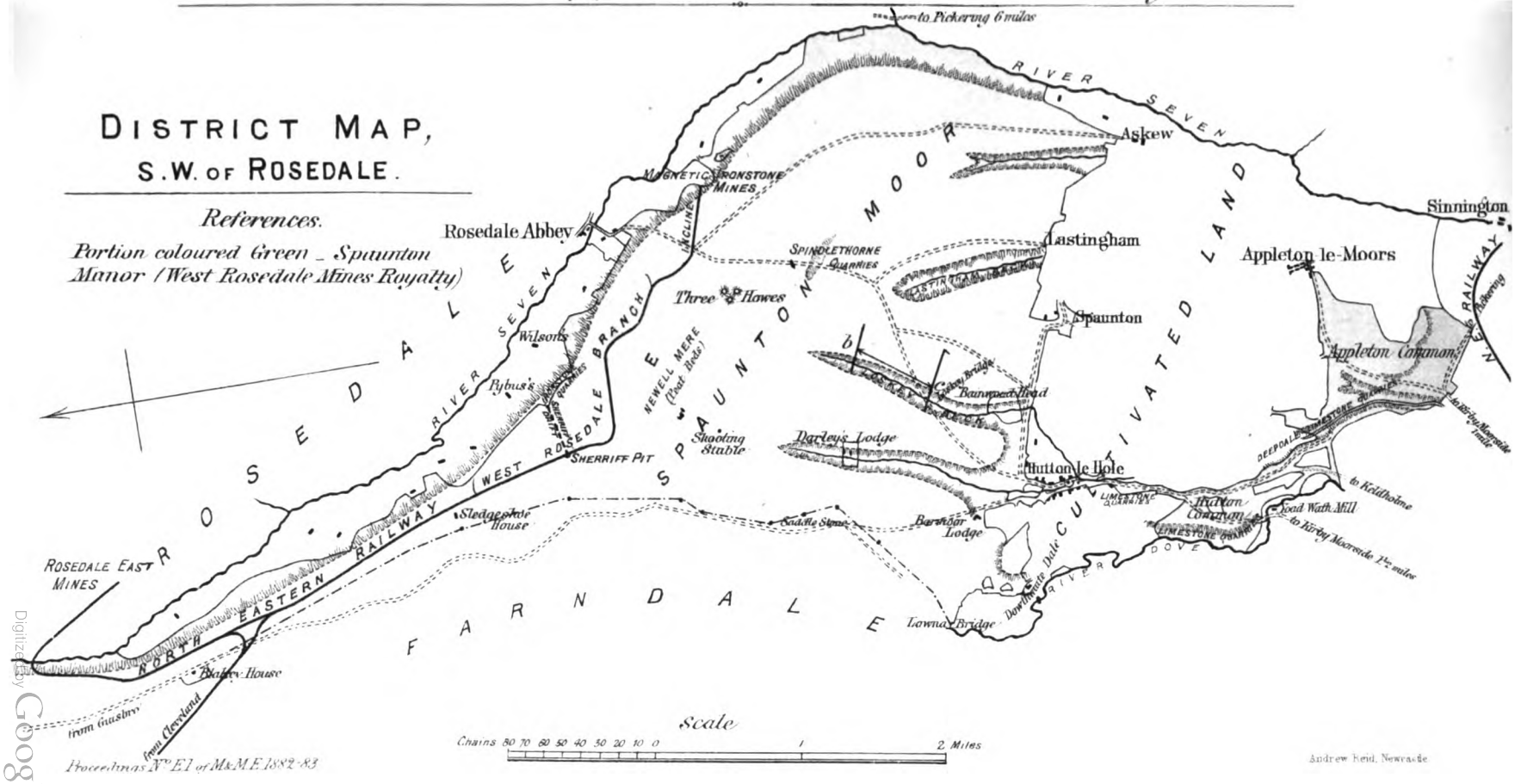
To illustrate Mr. Charles Parkin's paper "On the Mineral Resources of the Rosedale Abbey District."



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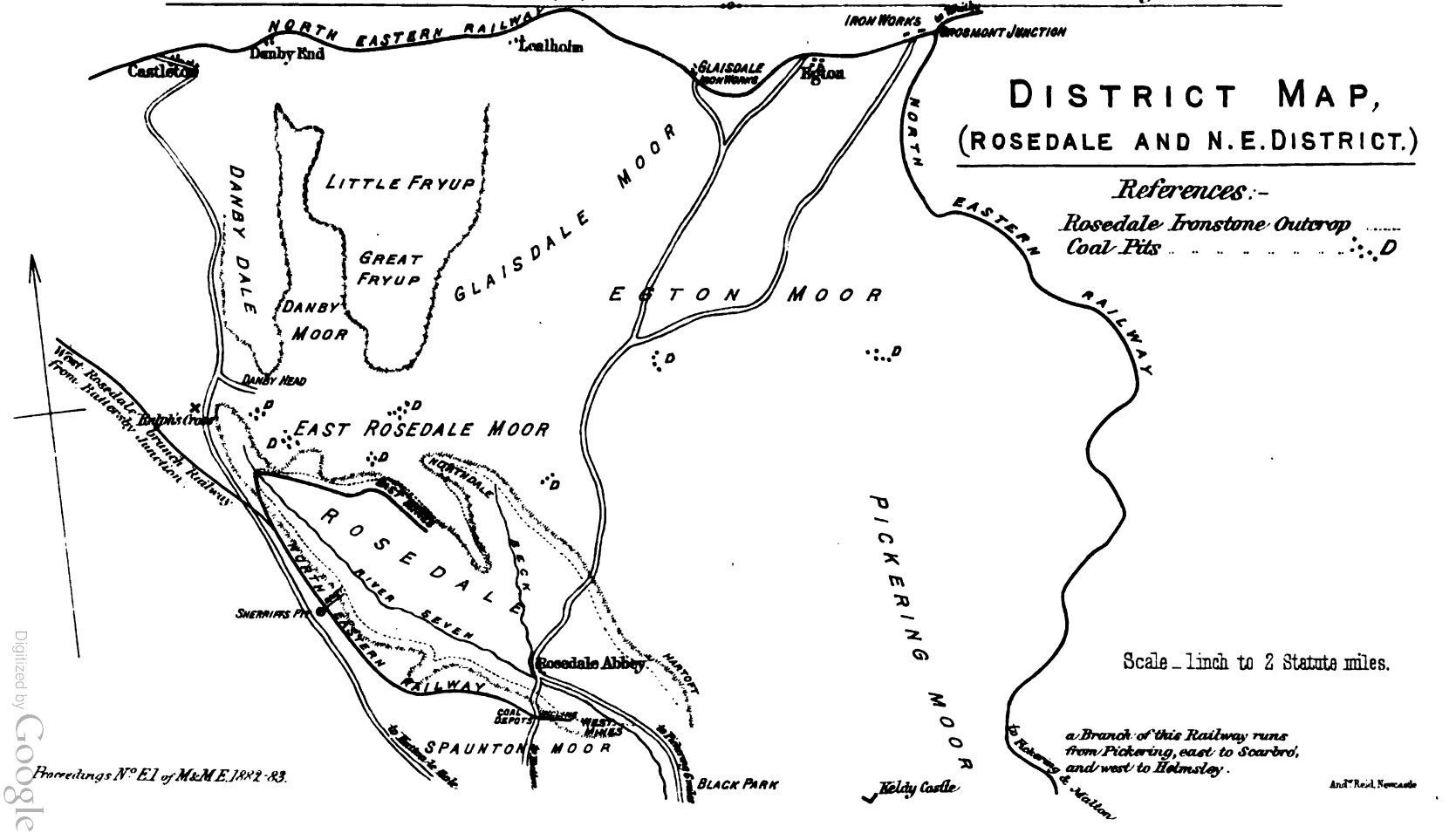

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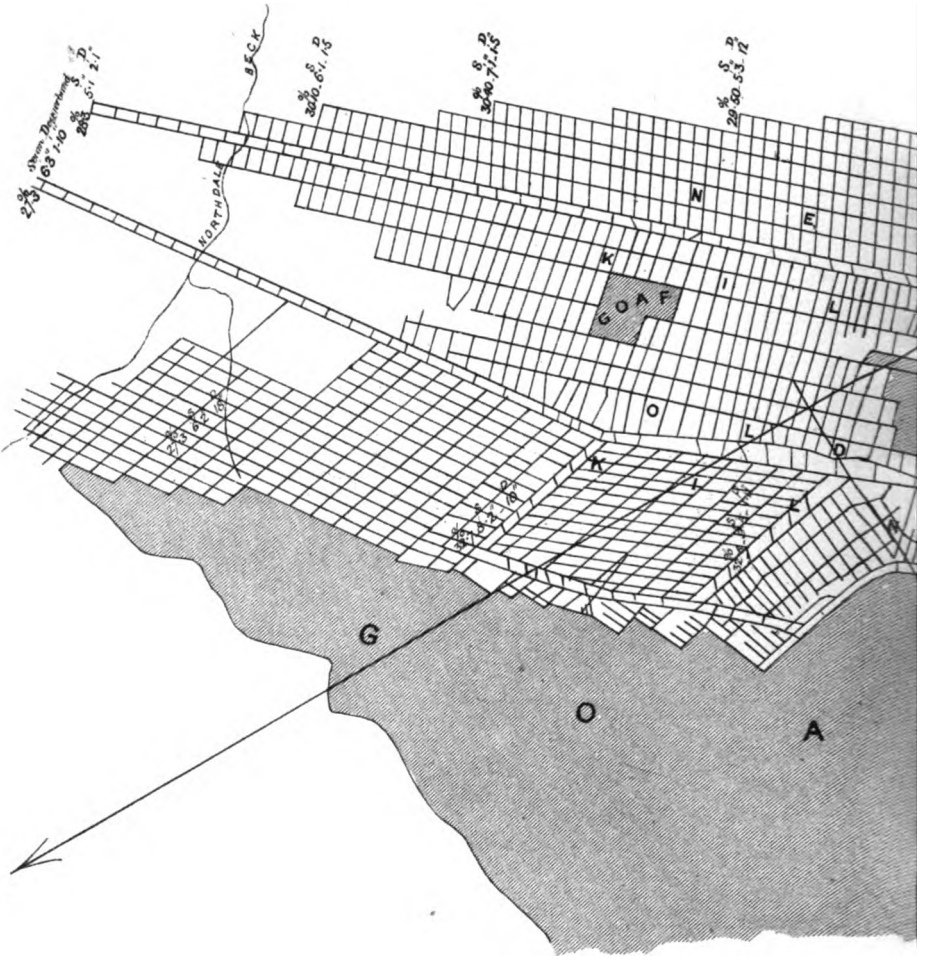

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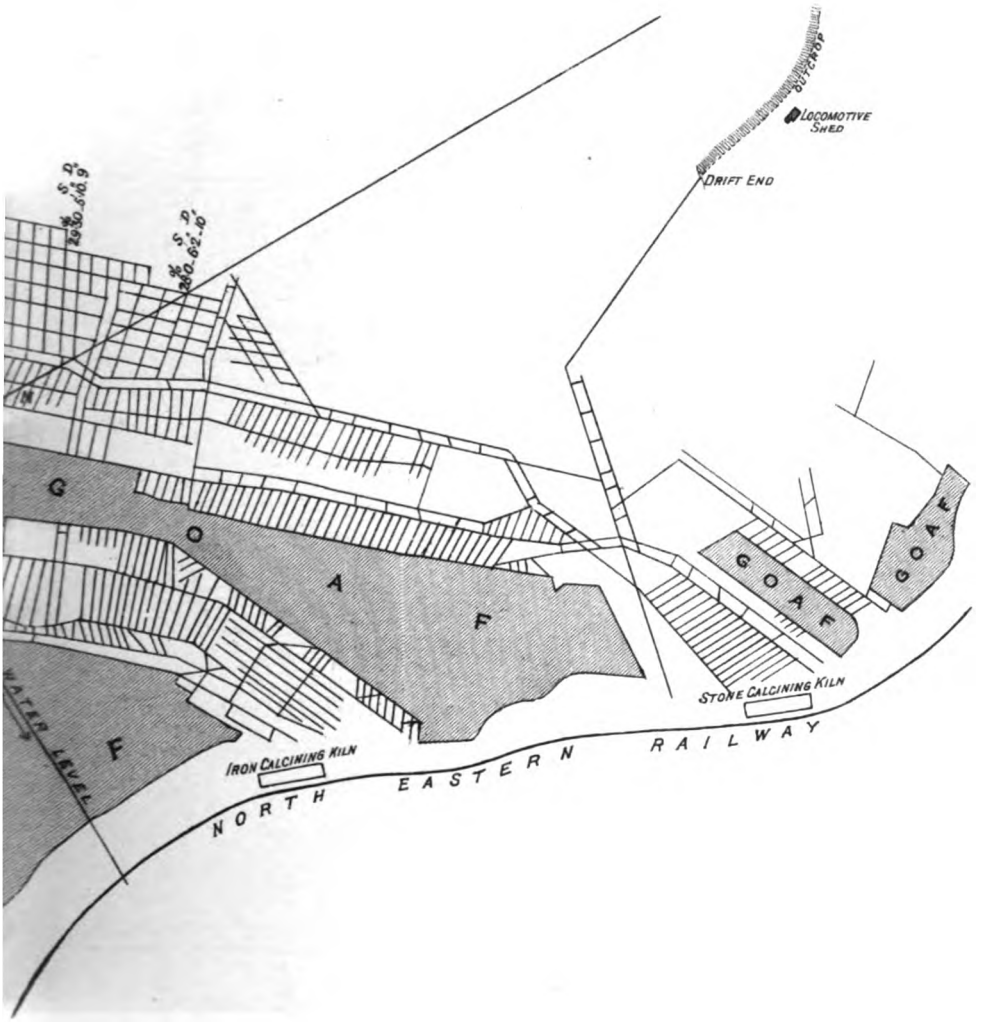

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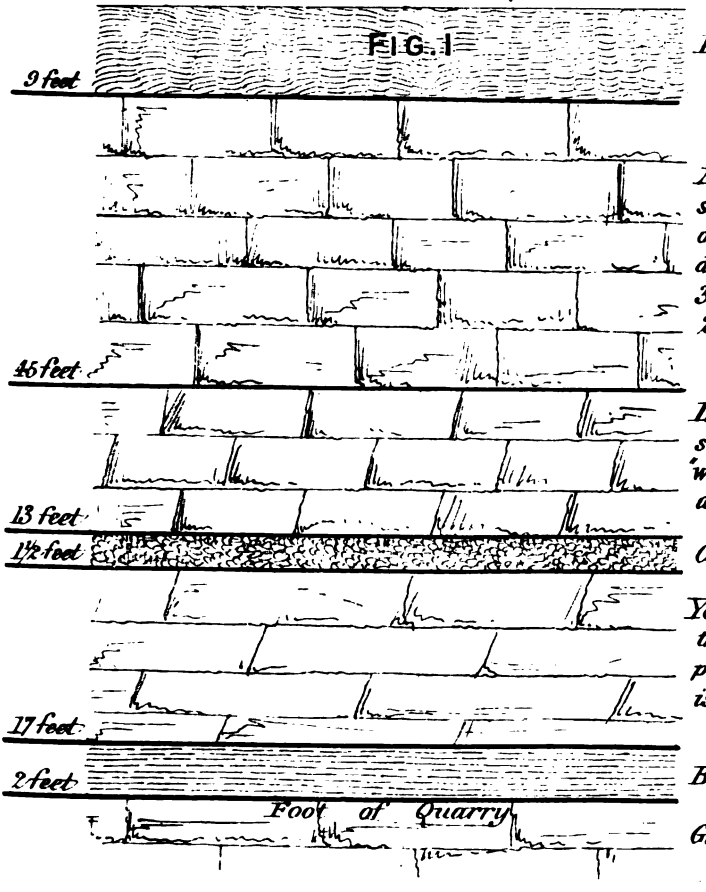
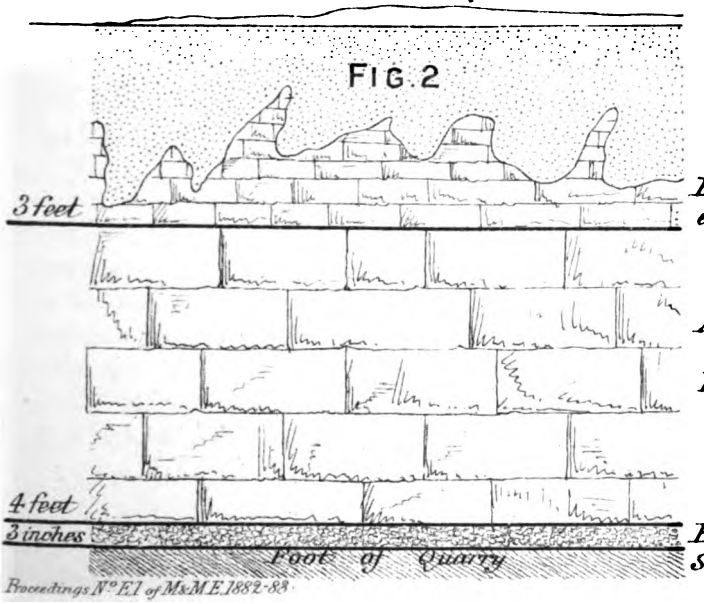
To illustrate Mr. Charles Parkin's paper "On the Mineral Resources of the Rosedale Abbey District."

Section of Limestone Quarry at Pickering.



Section of Road Metal Quarry at Spindlethorn.



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VISIT TO THE CHANNEL TUNNEL WORKS,

NOVEMBER 18TH, 1882.

AT the General Meeting which was held on the 14th of October, after the reading of Mr. C. Tylden-Wright's paper on the "Channel Tunnel," it will be remembered that Sir Edward Watkin invited the members of the Institute to visit the Tunnel Works at Dover. Subsequent correspondence with Sir Edward fixed the 18th of November as the day for the visit, and circulars were issued to all the members inviting them to attend. About 110 members expressed their desire to avail themselves of Sir Edward's kindness, and, at his request, a list of these gentlemen was forwarded to him. Sir Edward then took the matter into his own hands, and, with his usual liberality, supplied each gentleman with a free pass from his place of residence to Dover and back.

The party assembled on the platform of the Charing Cross Station of the South-Eastern Railway at nine o'clock in the morning of the 18th, and were received by Sir Edward Watkin, the Chairman, and Mr. Shaw, the General Manager of the Railway, and conveyed in the special train which had been provided for them to Dover. The party descended the shaft in batches of thirty, and were taken to the face of the Tunnel in carriages pushed by hand. Many, however, walked along the Tunnel with a view of more particularly examining the details of the work which had been executed.

The Tunnel was lighted by electricity, on the incandescent principle, and as a general description of the Tunnel has been given in Mr. C. Tylden-Wright's paper, it would be useless here to recapitulate the particulars.

The surface machinery is of the ordinary kind for compressing air, and does not seem to require any detailed description. The little compressed air locomotive, however, which was described in detail by Colonel Beaumont, elicited general admiration and was under the most complete control. It is built of a suitable size to go into the Tunnel, and was running

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about on a railway on the surface, laid on a curve and gradient of 1 in 80, corresponding to the heaviest duty it will have to do in removing the *débris* under ground. It consists of a reservoir, or air receiver, about 9 feet long and 2 feet 6 inches in diameter, with circular ends, welded up into one solid piece containing 60 cubic feet. The working pressure is from 1,000 lbs. down to 100 lbs. per square inch, and the reservoirs were proved by Messrs. Daniel Adamson & Co., the makers, to 1,500 lbs. per square inch; under this pressure they are absolutely without alteration of form. It is proposed to renew this test every year, and, at the same time, to wash out the interior of the reservoir with boiled oil to prevent any corrosion taking place. A large margin of safety is allowed, and at the same time it is impossible that the working pressure can exceed 1,000 lbs. A small quantity of water accumulates in the reservoirs during the working of the machinery and is let out occasionally by means of a small cock at the bottom. The air is conveyed from these vessels to two compound engines, working at right angles to each other, each having cylinders respectively of 2 inches and 7 inches diameter, and the valve gear, which forms a special feature, is so arranged that the air can be cut off in the small cylinder at any point from zero to full stroke. Under special circumstances, such as starting with a heavy load, the air can be admitted direct to the large cylinder.

One of the most interesting and important portions of Colonel Beaumont's invention is the use of a small boiler, not much larger than an ordinary hat, which receives its heat from a few handfuls of coke. The steam from this boiler jackets both the cylinders, and also heats the air before it reaches them. Working under normal conditions of load the heat so obtained enables the air to be expanded from 1,000 lbs. downwards without inconvenience, so that the whole, or a very large proportion of the whole, theoretical pressure due from this expansion is utilised, the air coming out at a temperature of from 80 deg. to 90 deg. causing no difficulty with the exhaust to be experienced.

The length of this engine is about 13 feet, its width over all 3 feet 6 inches, and its height from road level 5 feet.

The principle on which the engine is constructed may be summed up as one enabling high pressures to be used without the loss entailed by a reducing valve, and at the same time keeping the temperature of the air from dropping during expansion, without mixing air and steam together.

During the visit the Company supplied air to a couple of fixed reservoirs, whence it was taken, by adding a flexible hose, to the engine; the operation of filling, including coupling, did not exceed a couple of minutes.

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It is this arrangement which allows high pressure to be used with economy.

One cubic foot of air, at sixty-eight atmospheres, is produced from a consumption of one pound of coal, and it will haul a gross load of three tons (including the engine) one mile on the level portion of an ordinary well laid railway, a ton and a half on an ordinarily constructed tramway, and three-quarters of a ton on such lines and with such rolling stock as would be used in a colliery.

Colonel Beaumont stated that with large compressors and improved machinery the duty would probably be increased some 50 per cent. The machine under inspection had been very hurriedly built for the Channel Tunnel; but the engine Colonel Beaumont was introducing for mining purposes, while producing the same results, was very materially simplified.

For the information of those who were waiting to go below, a number of experiments were made with Smith's line cartridges, and large masses of chalk were brought down the side of the cliff. Professor Abel's dynamite shell, in which the dynamite is encased in a water cartridge, was also exhibited. A little before two o'clock the party left by special train for Dover, where they were entertained by Sir Edward Watkin at the "Lord Warden" Hotel, and returned to London by a special train arriving at about six o'clock.

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PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 9TH, 1882, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEO. BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

Professor G. A. LEBOUR and Mr. CHARLES Z. BUNNING were appointed scrutineers to examine the voting papers for the election of a Councillor in the place of Mr. W. R. Cole, deceased, and it was subsequently announced that Mr. HENRY LAWRENCE had been elected.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

ORDINARY MEMBERS—

Mr. SIDNEY FERRIS WALKER, Electrical Engineer, 195, Severn Road, Canton, Cardiff.

Mr. HENRY CHARLTON, Messrs. Hawks, Crawshay, & Co., Gateshead.

Mr. WILLIAM JOHNSON, M.E., West Stanley Colliery, Chester-le-Street.

Mr. JOHN E. COCHRANE, Consulting Engineer, Valuer, &c., Hetton-le-Hole, Fence Houses.

ASSOCIATE MEMBERS—

Mr. CHARLES DAVISON, Cornsay Colliery, near Esh, Durham.

Mr. JOHN WALES LAVERICK, Middridge Colliery, Shildon, *via* Darlington.

Mr. FREDERICK BERKLEY, M.E., Murton Colliery, near Sunderland.

Mr. JOHN LIDDELL, Coal Owner, Newcastle-on-Tyne.

Mr. THOMAS HUGH BELL, Coal Owner, Middlesbrough-on-Tees.

Mr. HENRY GREENER, South Pontop Colliery, Annfield Plain.

Mr. C. W. C. HENDERSON, Coal Owner, The Riding, Hexham.

Mr. C. J. BATES, Coal Owner, Heddon Banks, near Wylam.

Mr. ARTHUR PEASE, M.P., Coal Owner, Darlington.

Mr. ROBERT WATSON, North Seaton, Morpeth.

Mr. GEO. J. SCURFIELD, Hurworth-upon-Tees, Darlington.

STUDENTS—

Mr. WILLIAM RIDLEY, South Tanfield Colliery, Chester-le-Street.

Mr. JAMES MILL CRAWFORD, Murton Colliery, near Sunderland.

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The following were nominated for election at the next meeting:—

HONORARY MEMBER—

Professor P. P. BEDSON, D. Sc. (Lond.,) College of Physical Science, Newcastle-on-Tyne.

ORDINARY MEMBERS—

Mr. HENRY JOHNSON, jun., Sandwell Park Colliery, West Bromwich, So. Staffordshire.

Mr. MATTHEW LIDDELL, Prudhoe-on-Tyne.

ASSOCIATE MEMBERS—

Sir MATTHEW WHITE RIDLEY, Bart., M.P., Blagdon, Cramlington, Northumberland.

Mr. JOHN ALLAN, Eisernis Kreuz, Neugasse, Freiberg in Sachsen.

Mr. T. J. ARMSTRONG, Hawthorn Terrace, Newcastle-on-Tyne.

Mr. JOHN H. BURN, Coal Owner, 20, Broad Chare, Newcastle-on-Tyne.

Mr. JOHN BOWES, Streatlam Castle, Darlington.

Mr. CHARLES E. JEFFCOCK, B.A., Birley Collieries, Sheffield.

Mr. CHARLES LACY THOMPSON, Milton Hall, Carlisle.

Mr. F. D. JOHNSON, B.A., Aykleyheads, Durham.

Mr. A. E. BURDON, Hartford House, Cramlington, Northumberland.

Mr. WILLIAM THOMAS, M.E., Mineral Office, Cockermouth Castle.

Mr. JOSEPH SNOWBALL, Seaton Burn House, Northumberland.

Mr. ROBERT ROWELL, Seghill Colliery Office, Newcastle-on-Tyne.

STUDENTS—

Mr. R. NOBLE HAIG, Lofthouse Mines, *via* Saltburn-by-the-Sea.

Mr. ROBERT J. W. OATES, Mining Surveyor, E.I.R. Collieries, Giridi, Bengal, India.

The following were announced to have become Subscribing Members under the provisions of Bye-law IX.:—

The MARQUESS OF BUTE.

The BIRTLEY IRON COMPANY.

The following Paper "On the Feeding and Management of Colliery Horses," by Mr. CHARLES HUNTING, was then read:—

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THE FEEDING AND MANAGEMENT OF COLLIERY HORSES.

By CHARLES HUNTING.

The President of the Institute, Mr. G. B. Forster, having suggested to the writer that a paper on the management of horses would be acceptable to the members, as, up to the present time, this important subject had not been touched on in the Proceedings, he has much pleasure in placing the experience he has had during the last twenty years at the disposal of the members in the following paper.

The South Wales Institute of Engineers has often considered the question: once in Mr. James Brogden's Inaugural Address, 1876 (Vol. X., p. 14), and again in 1880 (Vol. XII., p. 285), in a paper by Mr. Wight, of Cwmaman Collieries, and in the discussion thereon (p. 395).

The importance of the subject requires little insisting on, when it is remembered that the horse department costs the Northern coal owners close upon a million sterling per annum.

Economic horse management consists in obtaining the greatest amount of work at the smallest cost; but here, as in every other department, true economy depends upon careful selection and well-judged method. Good food must accompany good work: neither should be disproportionate. It is difficult to say whether too much or too little of either is the worst economy. But good food and good work are not absolute terms capable of mathematical definition. What is excess of work for one horse is not for another: what is excess of food for one horse may be insufficient for another; or, again, the food required by a horse doing moderate work is insufficient for the same horse doing hard work. There is still another difficulty, viz.: that equal weights of food, of equal market value, may differ indefinitely in feeding value. These few statements will show that careful selection of foods, and well-judged method in proportioning them to the work done, are absolutely essential to economic management, and this skill and judgment require some scientific knowledge and some practical experience not always thought necessary in the horse manager of an establishment. The writer's knowledge of the subject has only been obtained by long experience, by freely accepting the work of others, and

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by submitting each theory or statement likely to be of value to a practical test. The subject is far from exhausted, but probably any further development must follow the lines laid down in this paper.

Tabular statements of the cost of feeding show absolutely nothing, save by comparison with others, and a comprehensive estimate should include not only the cost of food but the cost of horse-flesh and the amount of work done. By keeping too many horses to do a certain amount of work the bill for feeding can be made to look economical. By stinting the food an appearance of economy may be effected on paper, but the condition of the horses and the duration of their lives would soon dispel the illusion.

Both these explanations have been offered to account for the statements of economy embodied in the annual reports to the various collieries under the writer's charge, tabulated in the Appendix, page 107.

Economic horse management requires care in the conducting of the smallest details. From the purchase of the animal onwards, every step must harmonize and be subservient to the general object—economy.

In the selection of horses and ponies for "putting" work there is probably less discretion displayed by the managers of many collieries than in any other department. Hundreds of ponies are sold by dealers as three years old which have not lived twelve months, and it is quite common to find four or five in a drove of twenty, both Welsh and Shetland, especially the latter, not more than five or six months old, but which are always sold as two years old, and not one horse-keeper or owner in a hundred can tell by their dentition whether they are five or twenty months, in both cases the ponies having all "milk" teeth in their mouths. In numerous instances where the writer has been called in to examine colliery studs, he has found the pit ponies, not cobs, with no permanent incisor teeth visible, and when he has stated their age has been told "that he must be wrong because the pony had been a year and a half in the pit," but it was true nevertheless. He has seen several hundred ponies in pits, not two years old, that have been underground over a year. Their history is nearly always the same: "This pony has never done well since he came down; has a poor appetite, and has no life in him; does not work above half his time, and tires before half the shift is over." The overmen and drivers are always complaining because the new pony cannot draw the work out. The driver, being paid by the "score," has little mercy, and so such ponies are generally covered with scars and blemishes from ill-usage; their hocks and knees are twice as large as they ought to be; the poor brute is made to live in painful misery all its life, and the owners lose more than cent. per cent. in the keeping of a useless, or nearly useless, animal. In horses,

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the evil, in many colliery studs, is the other way; they are fine, fat, and good-looking, but their teeth show them to be far into their "teens," which means about two years' work instead of ten. The rule should be on all collieries that no horse should be bought under five years old nor over seven, and no ponies bought under three years old off. It is necessary that all animals should be examined by competent judges of age and soundness before they are paid for by the colliery.

Pit horses are probably the hardest worked animals in the kingdom, and hard work cannot be economically done by horses unless in condition; yet how very often it is that both horses and ponies are bought one day from a dealer, after being fed with boiled food and bran, and put to excessive work in the pit the next. In addition to the great risk of importing infectious diseases into underground studs, causing the loss of several hundreds of pounds, there is always tenfold more risk of injury to limbs and internal diseases from new horses out of condition than there would be from new horses well up to their work, which risk, in a well-regulated colliery, is always avoided by working all new animals for three or four weeks in the carts and wagons on the surface before going underground. It is very remarkable that such a palpable common-sense matter should be so often overlooked by the managers of collieries. The absurdity and cruelty of this is only exceeded by the still more common practice of working underground animals twenty to forty hours' shifts without their harness being taken off. There is nothing done on a colliery that is more expensive than overworking the pit animals double and treble shift.

Having secured a fair stud properly proportioned to the work, the next duty is to keep them as economically as possible, and this requires that they be kept in condition.

What is this "condition" which is so necessary? It is that state of the system in which nerve and muscle are braced to their full extent; that state in which the animal's body is capable of performing its greatest amount of work, and in which alone it is capable of sustaining prolonged efforts. If a horse is looked upon simply as a machine for work, this state is the only one in which it can be used economically. With it, the greatest amount of work of which his muscles are capable can be obtained; without it, a certain amount of mechanism is lying idle, *i.e.*, muscular structure, useless for want of tone. This state depends entirely upon a proper balance of food and work: as soon as an animal is overworked this balance is upset, and a state of being is commenced in which economy is no longer attainable.

There are two things necessary to produce condition in horses—work and food; or, rather, hard work and high feeding: the former is never

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lacking in collieries, and the latter can easily be attained if cost be no object. A sufficiency of oats and hay, with plenty of work, will produce condition, but at a most extravagant cost; but high feeding can be economically attained, and horses may be kept in the highest condition, at a cost very much below what is usually incurred for animals doing light work.

There are three conditions which render high feeding economical:—

1.—The selection of the cheapest but best food.

2.—Giving that food in a form most favourable to digestion.

3.—The prevention of waste.

The selection of the cheapest and best food is, of course, a matter to be settled in the first place by experiment, as have been the results now given; and in order that these results be accepted, their advantages must be understood. An outline of the rudiments of feeding will be given, ignorance of which reduces even the most extensive and careful practice to blind rule of thumb.

Long before chemistry and physiology rested upon any definite principles, experience had taught that certain foods possessed special feeding values. By the aid of these sciences it is now known not only which foods are most likely to be useful for any given purpose, but why they are useful; and, in fact, they enable the exact comparative value of the various feeding materials to be stated.

Food may be defined as a material which, when taken into an animal body, is capable of being changed and fitted to build up or replace the tissues of the body. Chemistry shows that these tissues consist of nitrogenous, fatty, and saline matters. It also shows that foods present a similar composition; so that, if the proportion of these constituents in any food is known, a fair idea of its feeding value is obtained. But chemistry alone is not reliable, as these constituents are not always in a form capable of being digested; and here physiology is useful, showing what is and what is not digestible, and also indicating how, under certain circumstances, some constituents are more essential than others.

This similarity of composition between animal and vegetable bodies will perhaps be more apparent by a glance at the following Table:—

Composition of	Dry Muscle.	Dry Blood.	Dry Vegetables.
Carbon	51·893	51·965	53·46
Hydrogen	7·590	7·330	7·13
Oxygen	19·127	19·115	23·37
Nitrogen	17·160	17·175	16·04
Ash or salts	4·230	4·415	...
	100·000	100·000	100·000

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This Table shows very clearly, from a chemical point of view, how closely animal and vegetable substances resemble each other. The body does not, however, appropriate the constituents of plants in the elementary form here given. These ultimate elements are, in the plant, combined in various proximate forms, suitable for the nourishment of the animal.

The following Table shows the comparative composition of animal and vegetable bodies in those more complex forms, and it will be noticed that again the comparison is very similar:—

PROXIMATE CONSTITUENTS OF

ANIMAL BODIES.	VEGETABLE BODIES.
Water.	Water.
Nitrogenous matter—	Nitrogenous matter—
Fibrine (flesh).	Gluten (oats, maize, &c.)
Casein (milk).	Legumin (beans, peas, &c.)
Albumen (eggs).	
Fatty matters.	Fatty matters—
	Starch, gum, and sugar.
Saline matters—	Saline matters—
Lime.	Lime
Potass.	Potass } Ash.
Soda.	Soda }
Iron.	Iron

In addition to water, the constituents of both animal and vegetable substances may be arranged in three great classes, nitrogenous, fatty, and saline.

The nitrogenous matter of the animal body is found under three forms, varying to a certain extent in their properties, in accordance with their derivation from flesh, milk, or eggs; but these three forms are similar in composition with each other and with the nitrogenous matter derived from plants, and all or any one of them taken into the body of an animal is capable of supplying all the three varieties. The gluten of oats, barley, and maize, or the legumin of beans, peas, and tares, supplies to the herbivora, forms of nitrogenous matter as suitable and as valuable as the flesh, milk, or eggs consumed by the omnivora.

The fatty matters of the body are not derived from the vegetable foods quite so directly as the nitrogenous. Animals make large quantities of fat when fed upon vegetables containing but a very small percentage of this article. The explanation of this is that vegetables, as the Table shows, contain ingredients—starch, gum, and sugar—which do not retain their original properties when taken into the animal's body. These substances undergo chemical changes, which convert the starch and gum into sugar, and, finally, the sugar into fat.

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These two great classes—nitrogenous and fatty matters—which are found in all animal and vegetable bodies, are those which have the most influence in relation to horse feeding, as the flesh or muscle of the horse is derived entirely from the nitrogenous constituents of vegetables, which may be designated as the flesh-forming matter. The fatty matters are derived from the fatty and starchy constituents of the food, and as the ultimate use of fat in the body seems to be its consumption for the production of animal heat, this class may be called the heat-forming matter.

The saline matters of the food directly supply the saline matters of the body, and they are quite as essential as the other two classes, but they are required in smaller quantities, and they exist in more constant proportion in each article than the other two. Of course, the composition of vegetable foods varies, and it is this variation that constitutes the difference in feeding value of each article.

The following Table gives a fairly correct idea of the constituents of a series of foods:—

	Water.	Woody Fibre.	Starch, Gum, Sugar, and Fat.	Nitrogenous Matter.	Ash or Saline.
Beans or Peas	14·5	10·0	46·0	26·0	3·5
Barley	13·2	13·7	56·8	13·0	3·3
Oats	11·8	20·8	52·0	12·5	3·0
Maize	13·5	5·0	67·8	12·29	1·24
Hay	14·0	34·0	43·0	5·0	5·0
Carrots	85·7	3·0 (Gelatine.)	9·0	1·5	0·8
Flesh	74·0	3·0	3·0	20·0	...

The large amount of water present in carrots and beef increases the comparative proportions of the other articles, all of which are in a dried state. Again, the column showing the amount of woody fibre is important, as this article is indigestible, and, therefore, almost useless as food.

The most important point, however, in the Table is this, that each substance differs in composition, some containing a large percentage of fatty or starchy matters, others containing a heavier proportion of nitrogenous matter. This theoretically suggests that some foods are most suitable for the production of muscle, others for the production of fat, and experience fully confirms the correctness of this indication. It will be noticed, however, that in every case the Table shows a higher percentage of starchy than nitrogenous matter. This is not because more fat-forming than flesh-forming food is wanted to meet the waste of tissue, but because

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a very large quantity of fat, starch, and sugar is applied in the body to keeping up the animal heat. It is, to speak properly, not only required for the renovation of the body, but as fuel for the use of the animal machine. To meet this double demand, it is found that the vegetable foods are always richest in these elements. No better illustration of the truth of these statements can be found than the practical success of the Banting system. That system, founded upon the above data, clearly proves that foods rich in starch, sugar, or fat will increase the fat of the body, but not add to the muscular strength; that lean meat, which is simply equivalent to the albuminous or nitrogenous principles found in vegetables, does not add to the fat of the body, but does supply the waste of muscle. The demand for these different constituents of food differs according to the state of the animal. In very cold climates the rapid loss of animal heat demands an excessive supply of the heat-producing foods: thus the Esquimaux consume enormous quantities of fat. Again, whenever the muscular system of the animal is greatly taxed a demand for the nitrogenous foods exist. Hunters cannot do their work on hay alone, they require oats and beans to supply the flesh-forming matter. The British soldier and workman has hitherto excelled in physical endurance and muscular power as much on account of his meat diet as his national qualities. The late Mr. Brassey found that when he fed his foreign workmen on the same diet as his British navvies the work done by the two approached an equality; previously they had no chance with Englishmen. Flesh, of course, supplies a heavy percentage of nitrogenous matter, but beans and peas supply even a much larger proportion, and their feeding value was well tested in the late Franco-German war, the German soldiers being largely dependent upon peas as an ingredient of their food to meet the waste of muscular tissue. The wonderful endurance of these men is conclusive evidence of the nutritive value of such food.

The value of the foregoing Table is enhanced when qualified by physiological knowledge, which shows that woody fibre is indigestible, and, therefore, an excess of it in any food is evidence of, at least, one disadvantage. It also teaches that a certain bulk of food is necessary to healthy digestion, and that, therefore, it is impossible successfully to feed entirely on those foods which contain the elements of the body in the most compact form. Further, the Table conveys a warning as to the action of different foods upon the digestive organs; thus, linseed, bran, and maize all cause laxness, whilst beans and peas tend to produce constipation.

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Thus, these articles of provender possess very different properties. Some are laxative, others constipative; but, by judiciously mixing them, both these objections may be removed and a most valuable food produced. To keep horses in health, when not hard worked, no mixtures are needed, and there is one grain in which the nutritive elements are so proportionately arranged that it cannot be improved upon, and practice has long adopted it. But to keep hard working horses in condition is a very different thing. Oats alone are not equal to it, nor can any single grain preserve both health and condition. The fact is, either their chemical constitution or their physiological action is defective, and it is only by mixing different articles, and altering their nutritive value, so as to balance physiological action, that a food can be produced which will not derange the functions of the animal, but which will supply all the requirements of the body.

Both chemistry and physiology then suggest that more than one kind of grain is advisable if economy and high condition are required. But the full economy of mixed feeding is only seen when considered with the money value of the different articles of provender in relation to their nutritive constituents, that is, when the feeding value is compared with the cost of the article. When the chemical, physiological, and monetary value of foods are understood, the cheapest and best food can be selected; or rather those articles of food which, when mixed in proper proportions, afford the largest amount of feeding material, at the smallest possible cost, can be recognised. Thus, and thus only, is the highest feeding compatible with the strictest economy.

If, in the feeding of horses, cost were of no importance, so long as health and condition were obtained, a large proportion of the advantages of using mixed food would be lost, as, unquestionably, oats and hay alone are a very good diet for horses not excessively hard worked. Such materials are, however, 30 per cent.—sometimes 50 per cent.—dearer than other provender equally valuable for feeding. Not unfrequently, when advising the use of a larger quantity of peas, barley, or maize, to a proportionate quantity of oats, it has been asked "whether the change, although the ingredients are cheaper, would make as good food? Look at the Scotch; see what strong, healthy, muscular men they are, and many of them subsist almost entirely on oatmeal." This argument is easily refuted. In the first place, oats are not oatmeal; they contain 30 to 40 per cent. of husk—indigestible material, equal in feeding value to chopped straw. This husk has to be paid for at the rate of 500 per cent. more than it is worth as food. In every ton of oats are 7

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or 8 cwts. of husk, which costs at the rate of from £8 to £12, whereas it is only worth £1 per ton, the price given at the manufactories. Secondly, although the Scotch labourers, as a class, are fine, big men, they are decidedly inferior in muscle and "condition" to the pitmen of Durham and Northumberland, who eat daily from 12 to 24 ozs. of flesh food. There is probably in no part of the world a class of men equal in muscular tone and condition to the coal-hewers of Northumberland. The "pit-heap" of a large colliery, when the men are assembled to go down, is a sight worth seeing for many reasons, but nothing is more striking than the enormous muscular development of limbs, chest, and shoulders displayed by the majority. Change their diet, substituting oatmeal for meat, and a diminished output of coal and a reduction in the size and tone of their muscles would at once be apparent. To hard-worked men oatmeal is no efficient substitute for beef and mutton, and for hard-working horses oats are inefficient as compared with beans and peas. Experience shows this most plainly, and science explains it by showing that beans, peas, and tares are almost identical with beef and mutton in the amount of muscle-forming material contained by each, whereas oats contain nearly 50 per cent. less than either of them. Now, in horses or other animals excessively worked, the consumption of muscle is far in excess of the waste of other tissue, and the blood must be supplied by a correspondingly large amount of flesh-forming material. To fulfil this requirement, food containing a heavy percentage of nitrogenous material must be given, otherwise the digestive organs will not be able to supply the requisite pabulum to the blood. Beans or beef will supply it, oats or potatoes will not, even when an extra amount of them is given; because this entails the consumption of such an immense bulk of material, a large proportion of which is indigestible and non-nitrogenous, and the digestive organs are overpowered and unable to reduce the mass to a state in which all its value may be absorbed. For these reasons, then, the use of oats as a principal article of diet for excessively hard-worked horses is very expensive, if not injurious. Scientific and practical observations are thoroughly in accord as to this fact, the truth of which was forcibly demonstrated at a colliery in Durham, which fell under the observation of the writer some time ago. The output at this place was decreased from fifteen to twenty scores per day through the horses being unable, from want of condition, or from positive debility, to get the work out. These animals were miserably poor, though allowed 168 lbs. of oats and 154 lbs. of hay each per week. The oats were not crushed and the hay was not chopped. The horses were all large; none under 16 hands, many 16·2.

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They worked very long hours and took heavy loads, but their appearance was lamentable after many months of such apparently liberal feeding. On September 1st their food was changed to the following:—

	s.	d.
Crushed peas, 35 lbs., at 34s. per qr.	2	4
„ barley, 20 lbs., at 28s. „	1	3
„ oats, 40 lbs., at 28s. „	3	4
Bran, 14 lbs., at 7½d. per stone		7½
Hay, 7 stones, at 9d. „	5	3
	12	9½

The old plan being:—

	£	s.	d.
Oats, 168 lbs., at 28s. per qr.		14	0
Hay, 11 stones, at 9d. per stone		8	3
	£1	2	3

Showing a difference of over 9s. 5½d. per horse per week. Besides this saving in money, the digestive organs had 56 lbs. less hay and 59 lbs. less corn to digest, or—

	Lbs.		Lbs.
Mixed grain ...	109	Old oats	168
Hay	98	„ hay	154
	207		322

Within three months this stud of horses was in excellent health and condition, drawing out of the pit, with no application of engine power, from twenty to thirty scores more per day than when first attended. There were 149 horses on the colliery, so that a saving of £3,664 3s. 2d. per annum was effected, which alone was a satisfactory result without reckoning the increased work performed and the increased value of the animals, which also amounted to a very considerable sum. The marvellous change effected in this stud is conclusive evidence that oats can no longer usurp the position of being the best food for hard-working horses. If the choice is limited to a single kind of grain, experience has shown that oats are certainly the best, and science explains it by showing that the essential food constituents of oats are in better balanced proportions and in a more digestible state than in any other grain; but there is a degree of work sometimes exacted from horses which oats are not able to meet, but which can be met by means of well selected mixtures of grain.

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Not only are these mixtures equal to the task of balancing the excessive waste of the system induced by hard work, but they do so at a less cost than that at which oats fail to preserve the balance.

But the system here advocated does not rest upon this one case, nor is the question of feeding economically thus easily disposed of. A definite mixture, which should be in all cases and at all times the best and cheapest, is not easily to be found, for not only must the chemical and physiological value of a food be known, but also its money value; and this changes constantly. So that each article of food in its threefold aspect must be thoroughly understood. Before, however, each article of provender is considered in detail, attention will be drawn to some rough analyses of various kinds of grain, which, it is believed, throw some light upon the question of selection. At different times during the last six years Messrs. Ferry's steam mills, at Easington, have been engaged by the day in order that the grinding, sifting, and weighing of different kinds of grain, to ascertain the proportion of husk contained in each, might be personally inspected. The different results of each of the six years is so slight that only those obtained in 1868 will be referred to as a fair average.

In 1869 nearly all the grain experimented on gave a slightly less amount of husk than in any other year. It was all the produce of 1868, and the difference was due perhaps, rather to the husk leaving the kernel cleaner and easier, than to a positive decrease in its quantity. This idea derives some force from the fact that the year 1868 was very fine and hot, and corn was well ripened and well gathered.

In carrying out these experiments it was necessary to use three stones of each kind of grain, because the miller would not allow all the grain to run off the mill stones before adding more, which caused the grain to be more or less mixed with that which had preceded it in the mill. To prevent this contamination about 20 lbs. of each lot of grain was allowed to run through; this was swept away and 14 lbs. of the pure grain collected, which was carefully sifted through a fine sieve, and both husk and flour separately weighed so as to prove that the 14 lbs. of the sample was properly accounted for.

Oats.—If the choice of grain is limited to one variety only, oats are the best; and, if cost is no object, oats and bran form a food simply unobjectionable. But, as the following Table will show, oats vary considerably in value.

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TABLE SHOWING THE WEIGHT OF HUSK IN VARIOUS GRAINS

	Natural weight per Imperial Bushel. lbs.	Weight of husk in 14 lbs. of each. lbs. oz.
1.—Elbe oats	41	5 6½
2.—Swedish oats	39½	5 0½
3.—Danish oats	40½	5 2
4.—St. Petersburg oats	40½	3 14½
5.—Short Scotch oats	41	4 6
6.—English oats	41½	4 6
7.—Irish potato oats	42½	4 1
8.—Canadian oats	41½	4 12½
9.—English barley	56½	11
10.—Danish barley	54	15
11.—Taganrog barley	49	2 4
12.—English beans	69	1 6
13.—Egyptian small beans	61½	1 8
14.—Egyptian large beans	59	1 10½
15.—Riga tares	68	10½
16.—Hamburgh tares	57	11½
17.—English tares	68	10
18.—Canadian white peas	66½	7½
19.—Konigsburgh white peas	64½	8½
20.—Konigsburgh blue peas	66½	8
21.—Odessa maize	59½	5½
22.—Italian maize	60	5¼
23.—American yellow maize	62	5

Seeing that the husk of grain is nearly, if not entirely, indigestible, this Table shows at a glance which food contains the largest amount of indigestible material. Oats, on an average, contain 4½ lbs. of husk in every 14 lbs.; maize, only 5 oz.; and peas, 7 oz. The percentage of husk then is very heavy in oats and very light in peas and maize, so that if the digestible portions of these substances are equally nutritive there is a heavy loss in the use of oats.

But oats vary considerably in value. They should be sound, sweet, a year old, and their natural weight should be at least 40 lbs. per bushel. In a paper written in 1860, the writer stated that two bushels of good oats, with a natural weight of 42 lbs. per bushel, would keep horses in condition better than three bushels of oats at 35 lbs. natural weight. Further experience has shown the truth of this statement, and proved that heavy oats are really worth seven or eight shillings per quarter more than the lighter. When the difference in feeding value between light and heavy oats was first noticed it was considered to be due to the lighter grain carrying the greater percentage of husk, but the Table shows that Russian oats have a smaller percentage of husk than the best short oats; possibly

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being kiln dried, they leave the husk cleaner; yet it is certain that, weight for weight, foreign oats are unable to sustain hard-working animals like the short potato oats. There is, too, an objection to foreign oats. There is something either in or on many samples most injurious to horses. The writer has frequently been called to examine and report upon pit horses which were unable to stand their work, although allowed an *ad libitum* supply of oats. The complaint is always the same:—"The horses were all right till the last two or three weeks; since then they have lost flesh, are always sweating, are very weak, and knocked up before the shift is half over." Nearly all such cases arise from the use of foreign oats, and the change in the horses follows close upon the change in the sample of oats. The symptoms shown are: a tight, dry skin, loss of appetite, debility, and excessive staling; much the same set of symptoms as from feeding upon musty English or Scotch oats. These foreign oats are, however, nearly free from smell, and, therefore, their objectionable properties are probably due to some artificial preparation or to the changes caused by mustiness, the smell of which has in some way been removed. Many more cases of colic are observed when using foreign oats than when using good home-grown grain. Only last year a lot of Tartar oats, 34lbs. to the bushel, were sent to a colliery. They were first refused, but an owner who looked into the matter and pronounced them very good insisted upon their being used, saying he did not believe that a light natural weight was of any consequence so long as they weighed 336 lbs. per quarter. The result was, they had ten times the usual number of colic cases, with general loss of condition to the animals.

It has long been known that musty or kiln-dried oats are injurious to horses, but the really dangerous nature of some foreign oats is not appreciated.

In the *Veterinarian* for 1862 Professor Varnell reports a case in which a number of horses died from eating them. A Mr. Mitchell, of Leeds, bought twelve quarters of foreign oats, and when about half of them were used four horses died within a few days of each other. Poison being suspected, the contents of the mangers and stomachs were analysed and found not to contain any vegetable or animal poison. Suspicion next fell upon the oats, and an aged but healthy mare was bought for the purpose of testing them. She had three feeds a day; on the third day paralysis appeared, which was followed by death. The experiment was repeated on other horses, and a few days' feeding on these oats produced death in each instance. The oats had a musty smell, and when placed in water

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they quickly became matted together by a filamentous structure, the fibres of which crossed and interlaced each other. Some floated at the surface and some remained at the bottom of the vessel.

In the same volume of the *Veterinarian* is another report of the death of thirty-nine horses from feeding upon musty oats, the cause of mischief never being suspected till the injury was done. In few cases has the writer directly traced death to foreign oats, but he has often met with serious illness as the result of such food, and frequently noticed the filament just described in the cisterns attached to underground stables. Bad oats of all kinds should be utterly avoided. Even small quantities mixed with a bulk of good grain produce ill effects and soon spoil by contact that which was previously good.

Referring to the Table showing the proportions of husk on grain, it will be seen that oats show a very heavy amount—in fact, from 30 to 40 per cent. Now this husk has a value of less than 20s. per ton, whilst oats at 28s. per quarter are worth £9 6s. If the five thousand and odd horses whose feeding the writer superintends were fed, as they used to be, on hay and oats only, there would be a consumption of 134 tons of husk per annum. That is, a large quantity of material would be used costing £8 per ton more than it was worth, or more than it could be purchased for from the oatmeal dealers.

From these facts it may be concluded that the best oats are the cheapest; that though the market value of the heaviest oats is seldom three or four shillings higher than that of the lighter sorts, they are really worth seven or eight shillings more as food, and therefore are absolutely four shillings a quarter cheaper; also that musty or kiln-dried oats are positively dangerous, and should be utterly avoided. Foreign oats should be seldom used; they are generally light, and not unfrequently injurious There is, however, an objection to even the best oats as an economical food for hard-working horses. They contain such a large proportion of husk—*i.e.* indigestible matter—that their market value is out of proportion to their feeding value. One case has already been related showing how oats alone failed to keep in condition the horses on a colliery, and how a mixture of grain containing a larger proportion of nitrogenous matter succeeded in replacing and preserving their condition.

Beans.—Under this head are included peas and tares, for all three contain about the same proportion of nitrogenous or flesh-forming matter. Tares, however, contain a bitter principle which renders them somewhat objectionable.

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Between peas and beans there is no choice, providing both are in equally good condition. Sound, sweet, hard beans, tares, or peas, containing, as the Table shows, 26 to 28 per cent. of nitrogenous matter, are of all seeds the richest in flesh-forming material. They are then especially indicated for use when the animal body undergoes great loss of flesh or muscle, as it does with all hard-working horses. But these leguminous seeds cannot be used alone in very large quantities; they have a heating and binding effect upon the system. They must then be used either in small quantities or be combined with some other article of food having an opposite or counteracting effect. Such articles are supplied in bran and maize, either of which may be used advantageously in combination with beans, peas, etc.

Maize.—In 1861 the writer, whilst admitting that maize was a valuable food for cattle, pigs, and poultry, did not think it fit for horses. Further experience has, however, convinced him that he was in error, and that maize is really a most valuable article of provender for hard-working horses. The error occurred in this way:—In 1853 maize feeding was tried on the pit horses at South Hetton and Murton Collieries. The experiment lasted four days, and overmen, drivers, horse-keepers, and all complained. The food was changed immediately as about half the horses and ponies did not eat it readily; it was left in the mangers, and it was feared that as the animals did not seem to like it they might continue to refuse it, and thus lose condition and be unable to do their work. This made the writer for a long time very suspicious of maize as horse provender. He had also heard of its being tried in Glasgow and given up as unsuitable food. In addition, as its chemical composition showed a large proportion of fat and heat-producing matter but a smaller proportion of flesh-forming matter, he thus came to an adverse opinion of its value. However, it is still found that horses used to the ordinary oats and hay do not for the first few days feed freely on maize; but this is easily overcome by commencing with a small proportion mixed with the usual food and gradually increasing it.

The writer retained his adverse opinion of maize until 1867, when, coming one night from London with the late Mr. John Lawson, of Manchester, and discussing the different plans of feeding adopted in England and other countries, he strongly advocated the use of maize for horses doing slow but heavy work, and gave several instances of its beneficial use in Manchester, Liverpool, and Glasgow, where thousands of horses lived almost exclusively upon it and hay. Communicating with several gentlemen who used it, and finding that they all spoke in its

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favour, the writer visited Liverpool, Glasgow, and London, saw horses fed upon it, saw them at work, and came home convinced that he had published an erroneous opinion. Maize was then selling at sixpence per stone less than oats, which, on the number of animals under his charge, would amount to a difference of about £400 per week. Consequently, in 1868, the writer again commenced to use maize at South Hetton and at Ryhope Collieries. The complaints were as strong as in 1853, but having laid all the facts before the respective managers they allowed the experiment a fair trial. In a week all the animals took fairly to the feed—a mixture of one-third oats, one third maize, and one-third beans or peas. Varying the proportions of this mixture as any article became unusually dear, the plan was continued up to 1870, when all the bank horses at South Hetton and Ryhope Collieries were fed exclusively upon maize and beans—two-thirds of the former and one-third of the latter, and this has been continued up to the present time.

In March, 1873, talking with the manager of a colliery about the cost of feeding horses, it was ascertained that for nearly three years no oats had been used for the horses at bank, that they were never in better health or condition, and with his consent the same food was supplied with success to the animals below, and this experiment was the commencement of a saving of upwards of £6,000 a year in the keep of the pit ponies under the charge of the writer.

An important property of maize is its slightly laxative action on the bowels. Colic in horses is nearly always dependent upon or accompanied by constipation, and maize feeding reduces the risk of this affection to a minimum. During three years' use of maize, the eighty bank horses at Ryhope and South Hetton have shown only four cases of colic. The laxative effects of maize enable the use of very large quantities of beans, peas, or tares—so much so that equal proportions of maize and beans for excessively hard-worked horses can be used with the greatest advantage.

Two years ago a lot of horses were fed on maize and hay, another lot on maize, beans, and hay, the result being greatly in favour of the latter. Those fed on maize only showed as great bodily bulk, but not such hard, firm muscles. They were not so fresh at the end of the day's work, and, when excessively worked, were loose in their bowels; 3 lbs. per day more of the maize than of the mixed grain was allowed, but 98 lbs. a week of beans and maize kept the horses in better condition than did 119 lbs. of maize alone.

The use of maize is almost entirely limited to horses doing heavy work, and it has often been asked whether there is any reason why light

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harness and saddle horses should not be fed upon it. The writer tested this question with his own horses, and for the last ten years they have had nothing else, and never did they look better or do their work with greater ease. They are hard worked. In harness and in the saddle they do from sixteen to thirty miles a day, and the pace is not less than eight miles an hour. Surely this test is sufficient to convince any reasonable horseman that maize is a thoroughly good food for horses doing fast work, as well as for those doing slow.

There is just one objection to maize—it gives a disagreeable odour to the dung and flatus of horses fed upon it; but this is of no practical weight as compared with its value as a cheap and good food.

It is very remarkable how strong a prejudice exists amongst a certain class of fastidious horsemen or horse owners against the use of maize for feeding horses. There is scarcely any absurdity spoken against it that they will not believe, and without taking the slightest trouble to ascertain the truth or falsehood of the statements, propagate them in all directions as if they had discovered something of importance necessary for all men to know. Some of the statements are so extraordinary that it is only proper to notice one or two of them here.

A coal owner wrote last year that he had been told that a large Tram Company in Glasgow had discarded the use of maize entirely, because so many of their horses had died from its use. This statement was investigated and it was found that there was not a particle of truth in it. That for seven years past the daily food used consisted of maize, 12 lbs.; oats, 3½ lbs.; and hay, 10 lbs.; that their losses were considerably less than before they used it, and that diseases of the bowels had almost ceased. Only last year one of the owners of a colliery not far from Sunderland stated that it was reported to him by the manager that "maize had a strong tendency to produce 'grease' in the horses' legs;" and yet, with a stud of over 200 animals belonging to this gentleman, there was only one in the whole stud that had a "greasy" leg, and this was a bank horse that had the disease six years before. This same owner purchased a stud of twelve horses, only some two miles away from his colliery, about the same time, and the writer was called upon to examine them. They had never had a particle of maize in their food, yet no less than five out of the twelve had bad "greasy" legs.

Barley is usually looked upon as an unsuitable grain for horses: it is said to cause irritation of the skin. The writer has used it largely, and has not detected this or any other objection to its use, when the market price suggests that it is economical. It should, however, seldom be used

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in larger proportions than 25 per cent. of the total allowance of corn. It was not used in 1873, the reason being that the price averaged from twopence to threepence per stone more than maize. This difference in price is a matter of vital importance in the selection of an economic food, as one penny per stone on the price of grain amounts, on the aggregate of the horses under the writer's care, to £5,000 per annum. Barley is the staple food for horses in Spain, Turkey, Syria, and other Eastern countries. It is about equal in feeding value to oats or maize, for which it may be substituted when the relative price of these grains is such as to render it economical.

Barley during 1881 *and* 1882.—This grain has been the cheapest horse food in the market, and at a much lower price per stone than ever before known. In the autumn of 1881 any quantity could be bought as low as twenty-two shillings for 448 lbs., or about eightpence per stone, being sixpence half-penny per stone cheaper than oats, and twopence per stone less than maize, thus effecting a saving of many hundreds of pounds per month, over what the use of the same grain would have effected in 1880, showing most clearly the importance of regulating the quantity of each kind of grain by the price per stone in the market.

Bran of itself is not a food capable of feeding any animal. As an addition to other grains, or mixtures of grains, it is, however, of great value. Chemically, it is rich in nitrogen, but in practice it is found that this constituent is not in a digestible form, and bran is valued simply as a bulky, palatable article, having a laxative effect upon the bowels. It is then indicated as a useful agent for admixture with foods tending to produce constipation, or as a substitute for rich food when disease or idleness suddenly puts a stop to the regular waste of muscular tissue; in other words, when the demand for nitrogenous matter is wanting.

Hay.—No matter what grains or mixtures of grains are used, some bulky provender is required to enable the horse to properly digest his food. Hay serves this purpose, but it also supplies nutritive material, and, as an indispensable article of provender, requires proper attention. Considering its price, in relation to its feeding value, hay is very expensive. Its feeding value, too, is very variable, depending greatly upon its growth, the state in which it is cut, the condition in which it is harvested, etc. Good hay should be of quick growth, should be cut before the formation of seeds in it—*i.e.*, when in flower, and should be well won. It must not be stacked wet or too green lest it ferment, as this process detracts from its nutritive value. Even when all these particulars are attended to, hay varies in value

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according to the grasses it contains. One ton of hay composed of such grasses as Timothy, cock's-foot, dog's-tail, fox-tail, perennial rye grass, etc., is worth two tons of that formed of hen-pen or wild hops, mountain flax, rib grass, and other short, broad-leaved grasses that abound on poor undrained land. Over and over again the value of these two kinds of hay has been tested, and always with the same result—loss of condition among the horses, and a much larger consumption of the inferior hay. At South Hetton, the difference in cost from this cause, when the hay was £5 per ton, amounted to £15 per week.

New land hay has often been compared with old land hay, and 50 lbs. of old land hay found equal in feeding value to 60 lbs. of new. In 1868, when hay was selling at £7 or £8 per ton, the studs of two pits were put on old land hay. At the end of a fortnight the resident viewer reported that "the pit would soon be stopped, as the horses did not make half the manure they used to." It was a fact that, whereas formerly two tubs of manure were sent to bank daily, now only one and a half appeared. It was explained that the difference was in favour of the hay; that it was due simply to the smaller amount of indigestible matter present, and was a convincing proof of its economy; notwithstanding this the hay was changed. In a former paper this question was fully gone into, and the opinion then expressed has been confirmed by an experiment of a large coal-owner, who ordered the horses of one pit to be fed on one kind of hay and those of another pit on the other. This was done for several weeks, and then the experiment was reversed. In each case the result was the same, about twenty per cent. less old land hay being used, the corn remaining unaltered in quantity at both places throughout the experiment, and no visible alteration in the condition of the horses could be seen. This practical test is more reliable and useful than any scientific analysis, and its value is not decreased by its having been instituted for the purpose of upsetting the opinion it has so strongly verified.

Some years ago the allowance of hay on most collieries to wagon horses was twelve stones per week; to pit horses, ten stones, or more than double the quantity that with due economy is requisite. The tabulated reports show an average of under four stones of hay per horse per week. This is considered the amount compatible with economy, as excessive waste of muscle is best met by increased supply of corn. Some managers insist upon each horse-keeper having an *ad libitum* supply of hay, and thus the plan of feeding is interrupted by being in part dependent on the requirements of men instead of horses. Hay must not be looked upon as an addition to the provender, but as an important part of it, and its quantity must be

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regulated according to the amount of grain given, and the relative proportions of each must depend upon their respective prices, and the amount of work performed by the animal: also hay, from its form, is liable to be greatly wasted. An allowance of twelve stones of hay per week is never eaten by a horse, a large portion is wasted under his feet. In removing long hay from the rack or manger, portions are continually let fall by the animal, trampled on, and spoilt. At one large colliery, nearly a third of the hay sent into the pit was wasted and returned to bank with the manure; but even with care, unless the mangers are properly arranged, and the length of the hay altered by cutting, considerable waste is inevitable.

When English hay is very high in price, large quantities of Dutch and Belgian hay are imported into this country, and, probably with advantage to some horse owners, because when thousands of tons are sent in, it helps to keep the price of home-grown hay lower. In the early part of this year, when best hay was selling in Newcastle market as high as £8 10s. per ton, Dutch could be had at £4 10s. Dutch hay should never be used unless it can be bought at half, or a little over half, the price of best English or Irish "seed hay." One of the principal reasons why foreign hay is so inferior to English is the fact that it is always thrashed bare of its seeds, thus removing at least half its value as feeding material. Whenever foreign or Irish hay is bought, it should always be stipulated for "unthrashed," which is nearly double the value of "thrashed" hay.

There is probably nothing in foreign hay that is prejudicial to health any more than in English hay. The chief reason why it is so much objected to by horse owners is the fact that horses do not thrive so well upon it as on English. It is impossible that they should do so where the work is hard, unless an equivalent of corn is given to balance the loss of the seeds which are taken out.

Green Food is a valuable article of provender both for bank and pit horses, but it requires a little discretion in its use at times. Thus, in commencing its use care should be exercised by the horse-keeper not to allow each horse more than from six to ten pounds for his first feed, which should be at night and after he has eaten his corn. The next night from twelve to sixteen pounds may be allowed, and the next a full allowance may be given without fear of colic, as by that time the green food will have passed through the whole length of the digestive organs. When thus commenced with caution, from fifteen to thirty pounds may be given night and morning with advantage and economy. Green food should not be allowed in-bye or on the wagonways, because the drivers

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cannot be relied upon to prevent a tired and heated horse from gorging himself should he remain a sufficient length of time at the siding or flat. There is, too, a condition in which no green food at all is sent down the pit, namely, when the foliage is soaked with rain. Neglect of this precaution entails a larger proportion of cases of colic with the second than with the first crop. At the season when the first crop is ready for use, the weather is generally fine, but the second crop comes on when the weather is frequently wet and unsettled. An experience of many years' feeding of thousands of horses warrants the remark that, mindful of these precautions, green food is quite as harmless as any other provender; further, no provender is so cheap and so beneficial for a few weeks every summer. It is a splendid alterative, a restorer and preserver of health. It may induce a freer perspiration, but it does not destroy the condition: does not, as some suppose, render the muscles less hard and firm. There are many men who object to it, but there is no food or mixture of food that some men do not object to. They have objections to crushed oats, to chopped hay, and to peas and beans, but they have none to working a horse three, or it may be four, successive shifts. They object to all innovations, to everything save that to which habit and association have accustomed them.

During the last thirteen years the writer has devoted especial attention to green food feeding. The results of his observations will be interesting to those gentlemen who are free from prejudice and yet timorous as to the use of green food. The chief points to which attention has been directed are:—The daily consumption per horse; the comparative cost of green food; and its effects upon the health and condition of the horses.

This last item is the most important, as, if green food were prejudicial to the health or vigour of the horse it would be dear at any price. The beneficial effects it has, however, on the appearance of a large stud of pit horses is simply marvellous: the skin becomes looser and softer, the horses increase in size and weight, and these signs of health are not accompanied by any loss of muscular tone. So quickly does this improvement follow the use of green food that at times it has scarcely been credited to this sole cause; but repeated observation has now left no room for doubt. Those animals known as "bad thrivers," "small eaters," etc., and those whose skins are tight or unhealthy, present the greatest change for the better, being made literally into "new creatures." It is true that, when feeding on green food, horses perspire more than when fed on hard, dry food, and probably this increased action of the skin is the principal cause of the beneficial action found to arise from a few weeks' use of green food every summer.

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These facts require more than opinions or assertions to invalidate them; nevertheless it may be useful to reply to some of the objections occasionally advanced by men who say they want their stud kept like hunters—in hard condition, and who would give hunters green food? This desire is founded upon the false supposition that food because it is physically hard produces hard muscles; whereas it is exercise, and exercise alone, which gives to muscles this tone. Food is required, not to give any specific character to the system, but simply to supply the waste caused by exercise. The illustrations chosen to support the argument are equally fallacious. A grass-fed horse is not in condition, it is true, but it is because he is not at work — because his muscles are not exercised; besides, he lives entirely on grass, whereas the pit horse receives, in addition to his green food, a large amount of nitrogenous grain. There is, then, clearly no analogy between the two cases. Innumerable proofs of this could be produced, but the following was supplied by one of the owners of a colliery. In discussing the use of green food for horses during hard work, he related the following interesting particulars of what horses can do on grass:—A few years since, when travelling in South America, he rode from Buenos Ayres, all through Brazil, over the Andes to Chile, and on to Callao in Peru. His servant and himself had three cobs between them, carrying, with their baggage, not less than an average of fourteen stones for each animal; and they did thirty-six miles per day for five weeks; four days fifty-six miles were done per day, and the last day sixty-five miles, and all three animals were in admirable condition at the end of the journey, and their muscles hard and firm; yet they had only an occasional feed of barley or maize and long grass, cut as required by the groom when resting at the various stages or halting places on the journey. Such a test is the strongest evidence that can be given that green food is not injurious to horses whilst doing hard work. As to hunters, when in work they can get no green food, but there are few of them who do not have it at the same season as the pit horses—in summer. It must be remembered also that hunters are only in condition half the year, and that they are well groomed and cleaned and occasionally sweated. Pit horses, on the contrary, are in condition all the year round, are never thoroughly groomed and cleaned, and seldom sweat except from the most excessive labour or a hot position in the pit. Free cutaneous action is ensured in the hunter by clothing, etc., but is retarded in the pit horse, and this important point of difference between the two is partially rectified by the use of green food. Pit horses, like hunters, should be kept in the highest condition, but they

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cannot be kept alike; both require a sufficiency of proper food and proper work, but this must be regulated by the circumstances in which the animals are placed.

The increased perspiration accompanying green food feeding is supposed by some to indicate weakness; by others to be productive of weakness. That it does not produce weakness is shown by animals fed with it, and that it should not do so will be understood when it is considered that sweat consists of 99 per cent. of water, and this is a constituent of the body easily replaced at the cistern. Perspiration is not a true indication of weakness; of course it may depend upon an animal not being equal to the work, but it also depends upon the amount of fluid taken into the system. Green food contains a large amount of watery matter, and thus horses consuming it perspire freely. They do so, not because they are weak or wanting in tone, but because their systems contain an extra quantity of water. Hunters in hard condition usually sweat but little, because they are fed on dry food and limited in the amount of drinking water allowed; thus their systems contain no more water than can be easily excreted by the kidneys.

The writer has used green food in pits for thirty-three years, and his conviction becomes stronger with time that it is a most valuable article of provender for hard working horses. As a rule, clover and seeds are used, but green tares are equally good if not used till well podded, and only sent into the pit on dry days. Nearly ripe tares are the richest in flesh forming matter of all green provender, just as tares are the richest of all seeds used as food for man or animals. When commencing to feed the bank horses with tares, half the usual corn is taken off, and as the tares become nearly ripe many of the horses require no corn, but consume about 70 lbs. per day of green tares without visible alteration in health or condition, and without any reduction in their work.

The daily consumption of green food and its comparative cost cannot be better shown than by the following details. In June, 1874, 9½ acres of clover were bought for £57; on the 17th of June the horses began to feed on it, and it lasted thirty-one days. The weight brought to the colliery was 97 tons 7 cwts. 39 lbs., and the number of animals fed was 328 horses and ponies, or, counting two ponies as equal to one horse, 214 horses. Thus, over thirty-one days this averaged 33 lbs. per horse per day; but, as at the commencement from one-third to one-half the full allowance only was given, reaching full feed on the fourth day, each horse really had throughout the rest of the time about 56 lbs. per day. The whole of the hay was not, however, replaced by green food, for during this

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thirty-one days some 14 tons of hay were used, some for mixing with the corn and some for use at the flats or sidings whilst the horses were at work. The allowance of corn was reduced by 2 lbs. per horse per day. The result was, the animals gained in bodily bulk and did their work as well as usual, whilst a considerable sum was saved in the cost of feeding, as shown hereunder. The ordinary consumption of hay was 9 tons per week, or, for the thirty-one days, say 36 tons, which, at £6 10s., is £234. In place of this the following was substituted:—

14	tons of hay at £6 10s.	£91	0	0
97½	„ green clover, costing ...	57	0	0
		£148	0	0 = saving £86.

But 2 lbs. of corn per day less was used, and this, with 214 horses, gives for the thirty-one days 946 stones, which, at 1s. 2d., gives an additional saving of £55 3s. 8d., a total saving of £141 3s. 8d. in one calendar month, or little more than half the cost of hay.

Having now considered the various articles of provender in detail, and attempted to show the feeding value of each, and to point out in what particular each fails to afford singly an unobjectionable food, the different mixtures of grain which contain suitable proportions of nutritive material for the wants of an animal body undergoing excessive muscular waste remain to be descanted upon, and a few words will be added to show how the selection must be made dependent upon the market price of the different ingredients.

Mixed Food.—A mixture of oats, beans, and bran, can be formed capable of meeting any fair muscular waste. An equally good mixture may be obtained from barley, beans, and bran. Oats, maize, and beans may also be used, or simply maize and beans. Each of these mixtures is free from any objectionable property, and each of them contains a large amount of blood-forming matter. The question is, if all are good foods, which is the most economical? Perhaps no better answer can be given than that actually furnished by last year's prices Good old oats, 30s. 336 lbs.; good peas, 36s. 504 lbs.; good barley, 26s. 448 lbs.; and maize, 27s. 480 lbs.; good hay, £7 per ton.

Considering oats, maize, and barley as of equal feeding value per stone, and looking at the amount of nutritive material contained in each, it will be seen that horses could be fed at fully one-third less cost by using maize, peas, and barley, with a small quantity of hay sufficient for health, instead of oats and hay, in their usual proportions. This is shown as follows:—

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	s.	d.		Lbs.
Oats, 126 lbs., at 1s. 3d. per stone ...	11	3	Flesh formers	15·1
Hay, 140 „ „ 10½d. „ ...	8	9	„ „	7·0
	20	0		22·1

	s.	d.		Lbs.
Hay, 56 lbs., at 10½d. per stone ...	3	6	Flesh formers	2·75
Maize, 56 „ „ 9¼d. „ ...	3	2	„ „	7·25
Barley, 42 „ „ 9d. „ ...	2	3	„ „	6·75
Peas, 21 „ „ 1s. „ ...	1	6	„ „	5·75
	10	5		22·50

Difference in cost, 9s. 7d. per week, or £24 18s. per head per year in favour of mixed food, and rather more flesh-forming matter in it than in the oats and hay.

The reports of South Hetton and Ryhope Collieries for 1881 are practical demonstrations of the reliability and success of the above formula. At the present time, September, 1882, there is not such a marked advantage in the use of maize as there was in 1880, because good Scotch oats then cost 34s. per quarter, maize only 24s. per quarter, peas 36s., and barley 32s. Now, whilst oats have fallen 6s. per quarter, and barley 8s. per quarter, maize has risen 11s. per quarter, so that the relative cost of the feeding matter in the grains is considerably altered, but owing to the unprecedented low price of barley, 9d. per stone, it can be substituted very largely for maize with an enormous pecuniary advantage.

The fluctuations in the prices of provender are constantly occurring, far more so than one could possibly believe unless attention were carefully devoted to the subject. Thus, in 1879, maize was only 21s. per 480 lbs., whilst beans and peas were 40s. to 50s. 504 lbs., barley 36s. to 40s. 448 lbs., and hay £4 per ton. At the present time, 1882, maize is 35s. 480 lbs., barley 24s. 448 lbs., peas 36s. 504 lbs., and hay £7 10s. per ton ; or, in round numbers, maize and hay are more than one-third higher, whilst barley is one-third lower, and peas 5s. to 7s. per quarter less money.

No definite mixture can be offered as always affording an economical food. The cost of its flesh-forming ingredients must be calculated, and those selected which are cheapest, but it must not be forgotten that some articles cannot be used beneficially without another of opposite physiological action being added. Thus, if a mixture contain beans and no maize, bran must be added, and, therefore, in substituting oats for maize, the price and feeding value of bran must be taken into consideration as an ingredient of the mixture. These fluctuations in the

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grain market also show that capacious granaries should exist on all large horse establishments, so that, instead of buying from hand to mouth, whether provender be cheap or dear, owners may be enabled to buy largely when the markets are low, and sparingly when high.

The amount of provender allowed to a stud must be regulated chiefly by the work done, but as this cannot be calculated exactly, the condition of the horses must be taken as a guide, and thus a just estimate of what is required is soon arrived at. Every increase or decrease of work must then be followed by a corresponding alteration in the amount of provender, so as to preserve the balance between food and work. Never, however, should an error be made on the side of parsimony, as loss of condition is only re-established by an extravagant use of food.

Cutting and Bruising.—Having selected the food, or mixture of food, it is proposed to use, the form in which that food may be most advantageously given has now to be considered. The form in which the food is delivered is open to two objections. The long hay is wasted by the animals allowing a portion of it to fall under their feet, and some of the grain is liable to pass undigested through the alimentary canal. To avoid these sources of loss, it is advisable that the hay be chopped and the grain be crushed. Experience shows positively that these operations are productive of no ill effects. The additional expense they entail is many times repaid by the prevention of waste in the hay, and by the more complete digestion of all the grain eaten. It has been objected to these operations that they induce a horse to bolt his food only half masticated. To set this question at rest the following experiment was instituted. Four horses were fed on long hay and whole oats; four others on cut hay and bruised corn. The prepared food required ten minutes longer for its consumption than the whole. Possibly if the two articles, cut hay and bruised corn, were given separately, as is the usual provender, horses might eat it more quickly; but it is best to mix a portion of the hay with the corn, and thus the animal is obliged to thoroughly masticate both.

The grain is crushed, not to improve mastication, not to save the animal the trouble of chewing his food, but simply to break the envelope. It is not ground to powder, but simply split. No doubt horses with good teeth would well digest most of the grain they are allowed, but it should not be deemed satisfactory to lose any, and, therefore, all the corn should be reduced to a form in which, while it may still be well masticated, it is most favourable for digestion; to a form in which, even should it escape the teeth, it will not escape the stomach. The cutting of hay is advised

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for a different reason. It is not supposed that this mechanical operation affects its digestibility, but it prevents waste in the transit from the granary to the pit, it also prevents waste in the stall when the horse pulls a mouthful from the manger; above all, it causes the hay to mix better with the grain, so as to compel the horse to thoroughly masticate the whole of his provender. With long hay, frequent portions fall underfoot, are trampled on and spoilt; some horses, from mischief, wilfully throw their hay on the floor, and these little bits form, collectively, in a large establishment, a considerable item. By cutting the hay this waste is prevented, as the animal can only remove a mouthful at a time. The length of cut is almost immaterial, being equally effective if cut two inches, as if cut to half an inch.

Times of Feeding.—Almost of more importance than the form in which food is given, is the frequency and regularity of meals. The horse's digestive organs are not constructed for long fasts. Long intervals without food produce hunger, and hunger begets voracity, food is bolted, and indigestion and colic follow. This is doubly true and doubly dangerous with horses doing hard work. They come to their long-deferred meal not only hungry, but exhausted; not only is the food bolted, but the stomach is in such a state as to be incapable of thoroughly active digestion, and is overpowered by half the amount of food it could otherwise easily digest.

Waste.—The prevention of waste is best attained when a proper amount of food is given in a proper form; but there are two points to which it is right to devote some attention—the form of the mangers, and attention to the wants of individual animals. The mangers should not be less than 3 feet long, 18 inches wide, and 12 inches deep. They should have an upper border of wood projecting inwards for about 2 inches, and a transverse bar of half-inch round iron across the middle. A piece of 2-inch wide hoop iron, screwed on to the top of the manger, protects it from damage by the horse's teeth. This simple arrangement prevents the horse from throwing out his corn, and the provender is not left in so thick a layer as in the ordinary narrow and shallow manger. The second point is one which concerns the horse-keepers. Upon these depend the equable distribution of the food, and the attention to the wants of individual animals. In all stables of any size it will be found that differences of constitution, or different degrees of labour cause variations in the amount of food necessary for each horse. In a stable of 16 or 18 horses, some will be found in moderate, some in good, and some

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in very good condition, each having exactly the same food. Now, it is by the condition alone that the amount of provender required can be estimated, and therefore all the horses should be nearly alike as to condition. Of course there are some old horses and some which never look up to the mark, but setting aside these, a horse-keeper should know his work well enough to be able to increase or decrease the amount of food for each horse according to its wants. If all get exactly the same measure, it will be certain that some have too little and others too much; there is therefore waste—waste of the food left by some horses, and waste of condition in those which, it may be temporarily, require a little extra.

Horse-Keepers.—Too little attention is given to the selection of this class of men. On many collieries it seems to be understood that any decrepid old man who is no longer equal to the exhaustion of coal-hewing is fit to have charge of a stable. Now, the difference between a good and a bad horse-keeper is often sufficient to spoil the best arranged management. Food and work being equal in two stables, the health and condition in each vary in proportion to the skill and care bestowed by the horse-keeper. Regularity in attendance, feeding, and cleaning are essential. He must also take sufficient pride and interest in his work to keep his stalls, mangers, cisterns, and harness in good order, and he must have that knowledge of the habits and peculiarities of the animal only attained by long association with it, which is requisite to detect any little change betokening discomfort or disease. An old wasteman may possess these qualifications if his youth has been passed amongst horses, but this is exceedingly rare. Age is no disqualification for horse-keeping, but, other things being equal, youth and activity are preferable. Owners of horses surely know the difference between a good and bad groom. If this is felt by persons keeping horses for private use, how much more must its truth apply to the case of underground horses, where work is laborious and where stables and surroundings favour the non-detection of idleness and ignorance in the man who is supposed to attend to their necessaries and comforts. The writer has known four bushels more corn per week required by one man than by another, in a stable of fourteen horses, to keep the animals in the same condition.

It is very extraordinary how little attention is given to this subject by most viewers. Stables and stable management seem to be quite outside their calculations, as if it were of so little moment as to be unworthy of their special attention. Thus some viewers request a man to attend to thirty and even forty animals, feeding, watering, grooming, gearing and

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ungearing, and cleaning harness and stables, besides attending to sick and lame horses in the pit. The result is that no part of the work is efficiently done, and the waste of provender, waste of grass, and loss on the stud is tenfold greater than where each horse-keeper has, as a rule, a maximum of twelve horses or sixteen ponies to look after. This number is as great as the best of horse-keepers can possibly attend to with efficiency and economy.

In South Wales and in the West Coast Collieries ten horses are given to one horsekeeper to attend to, and this is far more economical than the thoughtless plan of giving large numbers to the care of one man.

The tabulated reports show both the actual and comparative cost of feeding at the respective establishments. The actual cost speaks for itself; the comparative cost shows the saving effected by the mixed food over the old mode of feeding. The comparison is made with the feeding in use the year previous to the writer being employed as horse manager. The old plan of feeding is obtained from the colliery books, and is calculated on the stock of animals kept and the total consumption of provender. The comparison is made by taking the actual quantities of provender consumed under the two systems at the prices paid during the year for which the report was made and the classification of the horses and ponies as to size is exactly as they stood in the books when the writer commenced. This matter of size requires attention, as it has a considerable effect upon the cost. It is one of the reasons why the absolute cost appears so much higher at some collieries than at others. For instance, at Ryhope, what are called "putting" ponies are as large as the animals classed as horses at some other collieries. Again, at Stella and Towneley Collieries, animals 14 and 14·2 hands are all classed as large ponies, whereas most collieries enter all 14 hands and upwards as horses. This matter of size, then, although it merely requires attention to prevent error in the comparison of two years' feeding at the same colliery, renders it impossible to accurately compare the cost of feeding at two different collieries even for the same year.

Attention should be also given to another point affecting the comparative cost shown by the reports, viz., that some of the collieries had before adopted a part of the plan recommended. They had used beans, peas, barley, and bran in addition to oats, and they had crushed the grain; thus the cost of the comparative year was already much lower than if the old plan of whole oats and long hay had been in force. This was the case at Cowpen and at Brancepeth Collieries: at the latter, this change had reduced the cost of each horse three or four shillings per week below that of the old

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system. At South Hetton, Ryhope, and North Seaton, the old plan was in use, and thus the comparative year stands higher, and a greater difference is shown in favour of the writer's plan.

The following particulars of the feeding at the principal collieries with which the writer is connected show the practical results of the method. The total saving in 1881 at these places was as follows: –

	£	s.	d.
South Hetton	5.655	15	2
Ryhope	6,031	5	5
Cowpen and North Seaton	3,343	7	3
Whitehaven	1,669	4	2
Bearpark	740	0	0
Backworth and Holywell	2,200	17	2
Brancepeth and Brandon	2,134	19	10
Seaton Delaval	2.720	3	11
Ouston and Urpeth	1,911	2	3
Haswell	1,644	15	1
Towneley and Stella	875	17	6
Mickley and Wylam	1,988	14	10
Trimdon Grange and Kelloe	1,143	15	4
Castle Eden and Hamsteels	2,708	19	7
Wearmouth	1.259	16	7
Bedlington	3.833	4	3
Corporation of Newcastle-on-Tyne	1,252	15	0
	£41,114	13	4

The following is a statement of the saving effected over a number of years at most of the collieries attended:—

	Years.	
South Hetton	31	£117.455
Ryhope	20	75,500
Cowpen and North Seaton	20	63,498
Whitehaven	15	23.511
Bearpark	6	3.880
Backworth and Holywell	21	35.797
Brancepeth and Brandon	13	29.143
Seaton Delaval	28	48.096
Ouston and Urpeth	4	7,263
Haswell and Shotton	5	10,586
Towneley and Stella	12	9,874
Mickley and Prudhoe	6	11,875
Trimdon Grange and Kelloe	31	46,079
Castle Eden and Hamsteels	6	11,713
Wearmouth	7	8,920
Bedlington	20	66,868
Corporation of Newcastle-on-Tyne	4	4,227
		£574,285

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But the saving in the cost of feeding by this method is not by any means the only advantage, or the whole economy effected, for it is claimed that horses do more work per annum, are in better condition, and last considerably longer than those fed on any other plan.

The writer has sound data to prove this assertion. To disprove some statements to the contrary, there was drawn up from the books of the South Hetton Colliery a tabular account extending over twenty-one years, showing the number and cost of horses, the cost of feeding, and the amount of coal drawn. (See next page.)

This information was obtained from the horse books, stock books, and from the case book wherein are entered the particulars of disease or accident, causing any animal to be a whole day off work.

The stock is taken every year, and the name, age, colour, size, and value of each animal entered. No animal is ever valued above the cost price. All new horses and ponies are entered in the horse book, with full particulars of age, colour, size, price, date of purchase, and seller's name.

Up to 1850 the only provender used at South Hetton was long hay and whole oats, with occasionally a few beans. At the close of that year the management was placed in the writer's hands, when crushing the oats and cutting the hay was commenced, and a greater variety of grain used.

The difference in the cost of feeding has resulted in a saving during the thirty-one years of £117,455, and the percentage of deaths from disease is less than half what takes place amongst agricultural horses.

The opinion of the late Messrs. T. E. Forster and Nicholas Wood, who in 1853 investigated the subject of length of service and annual deterioration of pit horses, was that they lasted from four to five years at the most, and that £5 per head should be allowed for deterioration. The following table shows that at South Hetton the average service was seven-and-a-half to eight-and-a-half years, and the yearly deterioration amounted to £1 12s. 3d. per head. The table only extends to 1871. The explanation is that in March, 1872, it was completed and sent to Mr. John Forster, of London, the principal owner.

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TABULAR STATEMENT, SHOWING THE NUMBER AND COST OF HORSES AND

STOCK—						
Dec. 31, 1850.	SOUTH HETTON—41 horses,	14 large ponies,	11 small ponies.
	MURTON	55 do.	23 do.	70 do.
		96	37	81

Value, £2,169 15s. 0d.

Year.	Horses Bought.	Ponies Bought.	Cost of Horses and Ponies.	Average Number of Horses and Ponies each Pay in the Year.			Cost of each Horse for Provender.			Deaths from Disease.		Deaths from Accidents		Destroyed, old and useless.	
			£ s.	Horses.	Large Ponies.	Small Ponies	£	s.	d.	Horses.	Ponies	Horses.	Ponies.	Horses.	Ponies.
1851	17	35	719 0	96	37	85	24	18	4	2	6	4	9	4	3
1852	5	9	234 10	63	32	75	25	1	0½	...	...	7	7	6	2
1853	14	63	1,085 10	62	30	93	27	1	0	2	3	3	8	4	3
1854	15	33	856 0	72	35	102	34	18	2	...	2	9	7	4	...
1855	10	20	933 16	66	38	99	29	19	1	3	...	7	2	6	2
1856	23	34	1,156 10	73	32	117	31	0	8½	2	...	1	3	...	1
1857	13	22	675 5	82	32	131	32	10	0	...	5	3	6	...	...
1858	2	24	345 10	79	31	132	27	14	1½	...	2	4	2	3	2
1859	10	20	712 5	75	28	144	27	8	2	2	...	4	6	2	2
1860	14	18	671 0	86	34	144	29	10	2	...	...	3	7	2	2
1861	6	18	363 10	92	33	149	30	7	6½	...	...	2	5	2	2
1862	7	19	382 0	87	24	150	26	17	6	...	...	5	3	1	2
1863	10	3	292 15	83	25	144	25	14	6	2	...	2	5	2	2
1864	5	23	390 15	77	24	143	24	19	1	1	2	2	4	...	...
1865	9	20	529 5	69	27	140	28	0	3	...	2	3	5	2	2
1866	10	31	857 10	75	28	160	29	9	1	2	3	3	4	...	...
1867	12	26	672 0	80	28	165	28	12	6	...	...	3	4	2	2
1868	22	28	915 15	96	33	170	32	16	4	...	3	2	3	2	2
1869	15	22	631 10	99	37	173	28	17	6½	...	...	4	4	2	1
1870	18	30	835 10	99	47	176	26	8	10½	2	2	4	9	1	2
1871	10	19	577 0	106	47	177	26	6	11½	1	...	6	6	...	1
Totals.	247	517	13,836 16	1,717	682	2,869	.....			19	30	81	109	45	33

SYNOPSIS—

Average number kept in each year for 21 years... ... horses, 82; ponies, 169.

Do. bought do do. ... ... do. 11·76; do. 24·42.

Do. died from disease in each year for 21 years, do. 0·90; do. 1·42.

Do. do. accidents do. do. do. 3·85; do. 5·19.

Do. destroyed in each year for 21 years (old and useless) ... ... do. 2·14; do. 1·57.

Cost for horses and ponies for 21 years, £16,006 (less, sold and stock, £7,511) equals £8,495, or ... £404 10 6 per year.

Cost for upholding 82 horses and 169 ponies, £404 10s. 6d. per year, equal to ... ... 1 12 3 each per annum.

Cost for provender per horse per annum for 21 years... 28 10 0

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PONIES FOR 21 YEARS AT SOUTH HETTON AND MURTON COLLIERIES.

STOCK— Dec. 31, 1871.

SOUTH HETTON	26 horses,	12 large ponies,	74 small ponies.
MURTON	70 do.	36 do.	101 do.
	96	48	175

Value, £5,181 0s. 0d.

Year.	SOLD TO: Various Persons. Horses.	Various Persons. Ponies.	Kelloe. Horses.	Kelloe. Ponies.	Trimdon Grange. Horses.	Trimdon Grange. Ponies.	Cash. £	s.	d.	Tons of Coals drawn each year.	Difference in favour of the present plan of feeding for each year. £	s.	d.	REMARKS.
1851	8	14	...	..	...	...	87	12	0	380,710	989	12	6	
1852	16	20	...	...	...	...	26	10	0	394,430	1,584	17	6	
1853	...	7	...	11	...	...	98	5	0	402,250	1,575	5	6	Putting Ponies introduced this year to South Hetton and Kelloe Pits.
1854	3	9	...	6	...	4	141	5	0	414,730	1,890	1	10	
1855	8	12	1	11	1	3	258	8	0	331,730	2,009	11	8	Twelve weeks' "STRIKE," several old Horses and Ponies sold and destroyed.
1856	1	4	...	4	...	5	112	19	0	470,080	1,848	7	8	1854-5-6, Horses very high in price owing to Russian War.
1857	2	6	..	2	...	...	39	11	0	507,260	1,965	12	0	
1858	4	3	...	6	...	1	106	10	0	562,200	2,310	17	2	
1859	1	4	1	7	...	3	153	4	0	561,700	2,279	1	3	
1860	...	7	...	3	...	4	78	10	0	608,850	2,352	7	6	
1861	...	...	...	...	...	...	.....			573,840	2,655	5	0	
1862	...	3	...	...	...	...	14	18	0	531,720	2,362	4	2	
1863	3	6	...	2	1	1	62	18	0	467,370	2,301	4	4	
1864	3	5	1	...	1	3	100	14	0	514,600	2,305	17	6	
1865	...	...	4	1	...	...	109	0	0	507,690	2,228	1	10	
1866	...	9	2	3	...	...	102	16	0	508,440	2,655	5	0	
1867	7	12	1	...	...	...	281	10	0	511,510	2,754	18	4	6 Horses and 5 Ponies sold to dealers, deducted from their bills.
1868	12	10	...	...	1	...	230	15	0	561,080	2,759	18	0	9 Horses sold to the Colliery Farms this year.
1869	2	8	5	...	...	1	133	10	0	601,701	2,912	0	0	
1860	5	8	3	1	...	2	118	10	0	677,409	2,370	19	6½	
1871	5	10	...	...	...	...	73	0	0	715,612	2,479	17	7	During 21 years 84 new Ponies sold to Kelloe and Trimdon Grange Collieries.
Totals.	80	157	18	57	4	27	2,330	5	0	...	46,591	5	10½	

Less cost of feeding at Kelloe, for 19 years	...	13,113	5 8
Less cost of feeding at Trimdon Grange, for 21 years		9,323	5 4
		£69,027	16 10½
Difference in higher price of provender for 21 years, over that charged in 1849	... ...	18,009	10 6
Total		£87,037	7 4½

LENGTH OF SERVICE AND HEALTH OF STUD.

2 horses and 3 ponies have been in the pits over 21 years each.

15 do. have been on the collieries over 14 years. and 12 others over 10 years each.

There are 60 ponies that have been in the pits over 10 years, 15 over 14, and 6 over 20 years each.

11 years out of 21 no horse died from disease, and 10 years out of 21 no pony died from disease.

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The following table will show the average duration of life of pit horses at several collieries, which is extremely satisfactory as compared with the results obtained by Messrs. T. E. Forster and Nicholas Wood, and that recorded by Mr. Wight in his paper already referred to, in which he says the average is only four years in the South Wales collieries, being but a trifle over half the period of the lives of horses in the collieries of the North.

AVERAGE LENGTH OF LIFE OF PIT HORSES AND PONIES IN THE UNDERMENTIONED COLLIERIES OF DURHAM AND NORTHUMBERLAND.

	Years.		Years.
Bearpark	12	Ouston	8½
Backworth	10	Trimdon Grange	8¼
South Hetton	9	Castle Eden	7½
Mickley	10	Hamsteels	8½
Stella and Towneley ...	10	Whitworth	8½
East Hetton	8¼	Ryhope	7½

The above averages are most satisfactory, considering that at least 75 per cent. of all deaths in the Northern collieries are produced by accidents in the pits. One of the most important modes of reducing the mortality of pit horses is the keeping of a "case book," in which every animal off work 24 hours is entered, with full particulars of the name and colour of the animal, nature of injury, and name of driver. This book is laid before the "head viewer" every bill day for his inspection and signature.

The very fact of the drivers and officials knowing that every animal off work will be brought before the head viewer is sufficient to prevent most of the gross cruelty in the colliery, and thus prolonging the lives of the stud.

UNDERGROUND STABLES.

There is nothing on a colliery respecting which there is so great a difference of opinion as underground stables and the ventilation of them. They are made in some collieries at a cost of £8 to £10 per stall, whilst at others 20s. per stall would cover them. Some have wide arched covering with dressed stone pillars, and the partitions of the stalls closely boarded up or built of bricks, whilst others have only two or three props, slight boarded partitions, and no other flooring than the stone or shale of the seam; others have them well ventilated by fresh air *ad libitum* passing through them and into the workings, whilst others shut off every foot of air when the animals are out of the stables and only allow of a limited supply when they are in, and this small supply after airing the stables is passed into the "waste" and so lost to ventilation.

Both these extremes are wrong. A very efficient pit stable may be made for about 30s. to 40s. per stall.

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After choosing a spot with good roof of not less than 16 to 18 feet wide with a good fall for drainage, a wall should be built 3 feet high, 3 to 4 feet from the coal wall, and the manger, made of iron or wood, or what is better than either, brick cemented inside, placed against it. The manger may be 2 feet long, 18 inches wide, and 15 inches deep, placed on a brick or stone base 18 inches high, with three or four props or uprights between the manger and the end of the stall, to which two pieces of 12-inch board should be nailed along the whole length of the stall, leaving 12 inches of the lower part and all above the 2 feet boarding open to the roof. To prevent one horse biting the other or eating out of his manger, a prop on the brick wall in front of the manger up to the roof should be put in, and four or five pieces of half-inch round iron put through this and the first long prop forming the side of the stall. The floors may be laid with bricks, or cement, or wood planking; the latter is best, but brick floors are the least expensive. Only one horse in ten lies down on a brick floor, two in ten lie on cemented floors without sawdust, and with plenty of sawdust seven in ten, and the same on wooden floors. These facts have been carefully noted in several pits, and it is a very important matter, because horses which never lie down become leg weary in a quarter of the time that those do that lie regularly in the stable. Scores of cases occur where horses that never lie down have become perfectly useless for pit work in two or three years through numbness of the legs, which causes them to stumble over the sleepers, fall down, and so stop the work. For such animals loose boxes should be made, and in nearly all cases horses that were comparatively useless have in three or four months become very valuable, doing pit work for several years after. In Ryhope pit this was very marked, the work being extremely heavy and the horses, sixteen hands and upwards, going with 10-ton loads. The viewer, seeing the great advantage gained, made one, and sometimes two, loose boxes for every stable, and this doubtless paid three or four per cent. for the outlay. At Lord Lonsdale's collieries the viewer had done the same thing and with the most satisfactory results. As no straw or bedding of any kind is allowed down pits sawdust should be used in as large quantities as can be had. It would be an enormous boon to the poor animals if some cheap and useful bedding could be had for them to lie upon. Probably if "peat moss litter" could be had for 20s. per ton it would pay for underground litter. This is mentioned chiefly in the hope that some gentleman will try it, and give the coal trade the benefit of his experiment, both as to its usefulness and its cost, after deducting the price of the manure sold from the pit.

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For inbye stables at South Hetton and Murton Collieries iron props and mangers have been used for many years instead of wood, both by Mr. Richard Forster and his predecessor, Mr. Matthews. The latter gentleman adopted them after the inbye stables caught fire at Hetton Colliery several years ago, costing that Company many thousands of pounds. They are constructed at a very reasonable expense, and are very durable and very safe against fire.

Plate XII. shows a novel pit stable by Mr. Wight, of Cwmaman Collieries, South Wales, which can be used as a loose box or stall. The advantages of this plan are set forth in his very excellent paper on "Underground Horses," already referred to. The cost per stall is as under:—

	Per Stall. £	s.	d.
Posts and fixing		16	0
Manger, wood and iron top		2	6
Gate with hinges		4	0
Wooden work for flooring		19	0
Total	£2	1	6

The novel part of the plan consists in backing the horse into the stall, instead of backing him out. The advantages are:—First, that the horses' heads and not their tails are of necessity always close to the main current of air. Second, that it is much easier to feed and water the horse when so placed than to carry the food and water to the other end of the stall. Third, being only upright posts between each "loose box" or stall, the free passage of air through the whole of the stable is greatly facilitated. Mr. Wight says:—

Upon the question of ventilating stables much prejudice exists. The prevailing method is to allow a split of fresh air to pass directly from the intake through the stables into the returns. This is a most pernicious practice, for in the event of any scarcity of ventilation the horses would be sure to be pinched the first, and the stables would become unwholesome, unhealthy, and the breeding-place of disease. Besides, the arrangement is an extravagant waste of air that might do important service in assisting to clear away gas in some far off point, instead of going direct to the "upcast." The only efficient way to ventilate stables is to construct them so that the air may come from the main intake of the district, pass through the stables, and then return back to the intake. When this mode of ventilation is adopted there is no inducement on the part of anyone to rob the horses of any portion of the air which they should have, for they would get the first of the air, which would be in a comparatively fresh and pure state. No other system of ventilation should be allowed, and the objections made by some that the smell of the horses would be intolerable should be met by saying boldly, that if there be not sufficient air in the district to carry off the smell of the horses the pit would certainly not be well enough ventilated to make it fit either for horses or men.

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Thousands of pounds have been thrown away on horse establishments and great suffering inflicted upon the poor horses through the non-application of this simple plan, and all sorts of "tricks" have been adopted by the overmen and master wastemen in collieries to make the head viewer disbelieve the complaints of want of air in some of the stables. One of these was so ingenious that it is worth pointing out. Many years ago the writer reported to the head viewer of a colliery that the air was so deficient in a large T shaped stable, that it would not move the flame of a candle placed on the floor; that 26 horses in the stable were breathing five times as quickly as they ought and sweating as they stood. The master waste-man and overman were sent for and both declared the ventilation good, and the air fresh and plenty of it, and that there must be a mistake.

It was arranged that an inspection should be made at five o'clock the next morning, and ten times the quantity of air was found to be passing along, that there was the night before. A lighted candle was ordered to be put on the floor and was nearly blown out. The writer protested that something had been done to throw more air into the stables since the evening before; the wasteman and overman contended equally strongly that nothing had been altered; but some months after it was discovered that trickery had been used. The farthest outlet of the T had been choked up, or nearly so, by a fall, thus preventing the air passing out of the stable; this was cleared out during the night, and as soon as the viewer had passed into the stable three or four brattice boards were placed across the wagonway between the first opening and the main stalk of the T, thus sending ten times the air through the stable that was passing the night before and causing the viewer to exclaim that he was never in a better ventilated stable. The men took care to have the brattice boards moved to the side of the wagonway before the main intake was reached.

WORK.

At the commencement of this paper, it was pointed out that the economic management of horses depended no less upon careful working than upon judicious feeding. Work, of course, must be proportioned to the strength and ability of the horse. It is evident that a horse only half worked is not an economic machine; it is also evident that a horse overworked is a source of loss, because the deterioration of the animal is then in excess of the value of his labour.

The greatest possible economy in the management of horses is attained when the work is level with the powers of the animal, and when these

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powers are thoroughly met by good feeding. By work, the muscular system of an animal is fully developed; by food, this state is sustained, and when it reaches its maximum—when the muscles are firmest, when the blood is richest, when every vital organ is most active—the point is reached at which an animal is capable of doing the greatest amount of work. This state is called "condition," and so long as economy is the chief object, all working horses must be kept at this standard. Underfeed or over-work an animal, and at once it is reduced below the point at which he is most powerful, and therefore most economical.

Unfortunately, the loss and injury caused by over-work, does not commonly show itself immediately and suddenly in a form to be detected by a novice. It is no such palpable and striking event as lameness or paralysis; it is the gradual loss of tone and strength, which entails more food, but no equivalent of work, and which gradually, but surely, shortens the life and destroys the value of the animal. As soon as a stud of pit horses are so over-worked as to lose condition, so soon is the horse establishment an expensive one, and the cost per ton for horse haulage is higher than it ought to be. Of those cases in which horses are worked till they drop down dead, there is nothing further to be said, and the writer would have preferred to have left the subject alone; because it is not, and cannot be, the duty of the horse manager to regulate the work done in collieries, as this rests with those who are much higher in authority, and who ought to know better. Feeding and working are, however, so intimately connected, that the economics of one cannot be considered independently of the other.

During the last fifteen years the writer has visited most of the large towns in the kingdom and inspected studs of horses of all kinds. He has watched them at work, noticed the pace at which they travel, and the weights they move; he has ascertained their methods of feeding and the cost; has seen them in the stable, and observed their condition, and been favoured with returns of their usual duration of service; and it may be broadly stated that no horses work so many hours as those in collieries, nor is the work so severe as in most of the pits visited in England and Wales.

Since the publication of the pamphlet on "Food and Work," eight years since, the writer has made careful notes of the relative amount of work done by horses on different collieries, the hours they work and the loads they draw, and the difference is incredible. Thus, at several large collieries in South Wales scarcely a horse did over 7 or 8 miles per day, and at no colliery did the average exceed 10 miles per day.

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A few years ago at one of the largest coal and ironstone establishments in South Durham, with a stud numbering 500 horses and ponies, the average distance travelled by each animal underground was less than half that travelled by the pit animals at Brancepeth, Mickley, Whitehaven, Delaval, Castle Eden, Haswell, and many other collieries attended by the writer. The horses in the ironstone mines travelled a less distance even than the pit horses; many of the horses took heavy loads, but none equal to the loads of the horses belonging to the Corporation of the City of Newcastle-on-Tyne. In fact, the latter horses have, for the last five years, been doing two-thirds more mileage per day than the animals in the ironstone mines of Cleveland. The cost of keeping this stud, which was fed on hay and oats, cost more by £10,000 a year than did an equal number of pit animals fed with mixed food in the way before described.

It is very difficult to compare the work done by horses under different circumstances, and it is equally difficult to say what is a fair day's work for a horse. To arrive at a definite conclusion all the circumstances affecting the work must be known. These are almost indefinite, including as they do the pace, the weight drawn, the kind of roadway, the gradient, the form and size of wheel, etc.

Perhaps no better idea can be given of what colliery horses do than by showing what distances they travel and what weights they draw on a nearly level road. At the Earl of Lonsdale's collieries, Whitehaven, there was a horse-road 1¾ miles in length. Each horse's journey up and down this way averaged about 19½ miles per day. On the journey out they brought about 7 tons, and on the return journey they took in about 3 tons of empties, so that they travelled 9¾ miles a day with 7 tons, and 9¾ miles with from 3 to 4 tons. This, however, is above the average distance for pit horses to travel. When the pits work regularly six days a week it is only by the greatest care that they can be kept in good condition; frequently, however, only five days per week are required.

More than eighty years ago a Dr. Dixon wrote a book on these Whitehaven collieries, and stated what the horses did at that time. "They used," says the doctor, "to work nine hours at a shift, and twenty horses drew about 42 to 44 tons. When the pits worked night and day there were three shifts of horses each working eight hours. The horses employed drawing coals from the face to the shaft travel where the roads are level from nine to ten miles a day; but where the roads are up an incline of three to four inches to the yard they only travel six miles

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per day." Compared with this the horses of to-day come out well, as in those same pits they travel double the distance and take four times the load they did in 1801.

Nineteen and a half miles a day is, however, too great a distance for pit horses to average. If it were practicable to put another horse on the road, and so reduce the mileage, there is no doubt it would be economical. But pit work cannot always be arranged so easily as carting or ploughing. Still there exists a good deal of false economy and not a little cruelty, which is avoided when the viewer is not only a clever mining engineer, but understands horses. No man wilfully over-works his horses, but some from want of special knowledge of the animal, and from anxiety to "get the work out," do so. They make the same mistake as a captain of a steamer, who, to obtain an extra knot an hour, burns £5 worth of extra coal per day, and saves in time about 20s. per day. The motive is good but the result waste. The average mileage in a fairly level pit, is about 14 to 16 miles a day. Some horses do not travel over 10 miles, others cover 20 or 25 in the shift, and even 28 miles per day in Murton Pit has been averaged for three or four months, the horse remaining in splendid condition. The rolleyway cobs in the C Pit, Brancepeth, did for years 24 to 26 miles per day, and the horses in the B Pit, Willington, for a whole year averaged 24 miles per day. This variation in distance depends chiefly upon the level of the wagonway. In pits where the roadway is very irregular and the gradients heavy, the work is most exhausting. Among the many instances where the effects of this variation in level are almost beyond belief, one in particular may be mentioned, where, in a certain pit there was a level plane half a mile long, over which one horse conveyed all the coal from the workings. Beyond this was an incline 200 yards long, of 7 inches to the yard, up which the same weight of coal had to pass. It required ten horses to draw the weight up the shorter distance, and, even then the ten could barely be kept in condition, by all the extra food they could consume. The horse on the plane was always in good condition. This horse, it will be observed, travelled four times the distance of the others, and took ten times the weight, and consumed 28 lbs. of corn per week less. So laborious is the work in some parts of collieries, that unless the particulars were noted no one could believe the marvellous difference caused by gradients on the work of underground horses.

A short time since when visiting the "inbye" workings of a colliery to examine the horses at work, the respirations of the animals, big sixteen hand horses, were taken, and some reached the incredible number of 145

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per minute, the hearts action being 122 per minute, and this after standing quiet for ten minutes; whereas the breathing of a horse in health, and quiet, should be twelve, and the heart's action 40 per minute. In these workings the gradient against the full tub was 8½ inches to the yard. The corn consumed by the horses was 13½ stones per week, and yet they were only in moderate condition, whilst other horses working on nearly level roads consumed only 7 stones per week, and were in splendid condition. The above cases are mentioned to show that where horses are overworked the cost of horse flesh is enormous; the waste of tissue is so great that nature seems to compel the poor animal to be always eating to repair the loss; but it is impossible that any horse could assimilate the amount of nutriment contained in 13½ stones of mixed food in a week, and hence the waste is twofold, loss in food and loss in horse flesh.

This matter of gradient is of far more importance when the roadway consists of iron rails, than when it is merely a macadamized surface. On a level way, a horse can take eight times the load in a truck running on iron rails that he can in a cart or wagon on any ordinary road; but when the way is inclined this is altered, and a rise of six to seven inches to the yard, reverses the power of draught, as then a horse will take eight times as great a weight up the road surface as he can up the rails.

This is the explanation of the enormous difference in the draught-power of pit horses on levels and on heavy gradients. Of course there cannot be pits without inclines, and, therefore, horses must work them; but it behoves all managers favouring true economy to avoid very heavy inclines, or to modify them as much as possible.

It happens occasionally on collieries that the grease is very bad, and it has occurred that a sample of some anti-friction material has been perfectly innocent of any such ingredient as fat. Such circumstances render the tubs almost immovable, and increase indefinitely the strain upon the horses. Fortunately, not only horses, but men and engines have to move these tubs, so that the evil is soon discovered, either by the breakage of the wire rope on the engine plane, or by its requiring two men to move each tub on the flat-sheets. In four or five days after the adoption of bad grease, a stud of horses has been so reduced in condition as hardly to be equal to work, each horse having lost at least four stones in weight. The gravity of this evil must be an apology for referring to it; certainly the loss of horse flesh has in some cases amounted to a depreciation of £2 per head.

In comparing pit work with other varieties of horse labour, it must be remembered that the wheels of the tubs are very small, and that the

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rails are not so well laid or so free from grit or dirt as the rails of wagon-ways at bank. When going, the horse is nearly constantly in the collar, and the pace is fully four miles an hour.

The writer has inspected and inquired into the working of studs employed on tramways and railways, in omnibuses and drays, and the various conditions in which wagons and carts are used. Time will not permit all these observations being introduced, but a sketch will be given of as much as may be necessary to give a comprehensive idea of the amount of work actually done by horses under different circumstances.

It is instructive to notice the difference in the length of time occupied by various classes of horses in performing their daily work. The tramway horses of most of our large towns are at work about three-and-a-half hours, omnibus horses seldom more than four hours. The maximum distance they travel is about fifteen miles per day. Cart and van horses, doing sixteen miles a day, usually work about eight hours; pit horses averaging twenty miles, and working twelve to eighteen hours per day.

To compare the labour done by these different horses, the stoppages must be taken into account, as well as the weight drawn, and the pace. Frequent stopping and starting with heavy loads adds very considerably to the amount of work done, and is most trying to the muscular system of the animal.

According to an article in the *Times* of December 10th, 1868, the horses of the London Omnibus Company averaged a little over twelve miles per day, their duration of service was four years, and the invalid and spare amounted to seven per cent. These statements may be considered indicative of good management.

The omnibus horses of Paris, in 1873, worked four hours per day on the following allowance of food:—Hay, 9 lbs.; oats, 20 lbs.; beans, 1½ lbs.—certainly in this country extravagant feeding. The average distance travelled was about fifteen miles. The streets are very level, the horses in very good condition, but the pace was only about half that of the Edinburgh tramway horses.

The Liverpool omnibus and tramway horses travel over fifteen miles, and are at work three hours. Exclusive of stoppages the pace is about six miles an hour. In Edinburgh the tramway horses travel over sixteen miles a day and are at work three hours. The pace is too fast, and part of the road is an incline which is a very heavy pull, although an extra pair of horses are employed to assist each tram-car over it. The effects of the pace, distance, and gradient are noticeable in the condition of the horses,

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which, however, are fed almost exclusively on oats, and are therefore not on a level footing with most of the others mentioned, which are allowed a proportion of beans.

At a meeting of the British Association, held in Dublin, it was stated that Pickford and Co., the great carriers, found they could not work their horses more than ten miles a day with economy. Mr. Bianconi, the well-known founder of the car system in Ireland, whose experience has been gathered from the working and management of 900 horses, which daily draw 67 conveyances a distance of no less than 4,244 miles, stated that, as the result of forty-three years' experience, he had found that he could better work a horse eight miles a day for six days in the week than six miles a day for seven days. By the one day's rest per week he effected a saving of 12 per cent.

The writer's own experience leads him to think that Mr. Bianconi has understated the working power of horses, but no one can be in a position to estimate the value of his assertion till his method of feeding and the circumstances affecting the working of the horses are known, but fourteen miles would seem more reasonable as an average day's work for a horse; certainly there can be no work above ground at which this distance could be called excessive.

There is another point to which attention should be called, viz., that it is the latter portion of a journey which tells most upon a horse. The last half of a ten mile stage is far the most exhausting, and therefore when it is possible to divide the daily work into two portions, separated by a long interval of rest, an economy is effected. Some have found by experience that it paid better, in horsing a stage-coach, to run the horses six mile stages at twelve miles an hour twice a day, than ten mile stages at ten miles an hour. This was an unexpected discovery, due to opposition making a fast pace indispensable, and the short stages were adopted to try and modify its evil effects. These horses were fed on white peas, bran, and hay. Of course this arrangement only holds good with horses doing fast work.

To sum up the deductions to be gathered from these facts, it may be remarked that more horses are under-fed than under-worked. That pit horses are usually over-worked. That the economic regulation of food and work is a subject requiring more attention than it usually receives, and that when these matters are properly attended to, the cost of a horse establishment is brought to its very lowest point—to a point much below what is usually thought necessary.

Over or Under-horsing.—Just as the over or under-working of one horse is false economy, so the under or over-horsing of an establishment

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is attended with unnecessary expense. If over-horsed, the extravagance is self-evident; but it is by no means generally understood at what point an establishment is properly horsed. Of course it can safely be said it is not so when a full allowance of good food is given and the horses lose condition; but there are many cases where, to all appearances, horses are overworked when really they are not doing the amount of labour they are capable of if only properly fed. Before, then, it can be concluded that an establishment is under-horsed because the horses are unequal to their work, it must be proved that the food is sufficiently nitrogenous to fully meet the waste of their systems. Given that the food allowance is unobjectionable, the horsing of an establishment may be judged very fairly by the condition of the horses, because when once the daily maximum amount of work a horse is capable of doing is exceeded, loss of condition follows inevitably, and loss of condition is equivalent to loss of money. When a pit is properly horsed the animals are kept in condition by good economical feeding, and they do their work not only with ease and comfort but without the loss from disease, injury, and death which surely accompanies the excessive work due to under-horsing. Death causes a loss appreciable to anyone, but disease and injury sometimes cause even greater loss because these animals still require food and attention without yielding any return of work.

Under-horsed establishments always show a high annual cost for food. They always have a number of incapable, and therefore expensive, animals on the place, and the average duration of service is much shorter than on those establishments where the work is fairly proportioned to the number of animals kept.

It cannot be too often repeated that a horse is only capable of a certain amount of labour. No amount of extra food can exact work beyond this point, because the nervous depression caused by exhaustion so affects the functions of the body that the food is not assimilated and the waste of tissue is in excess of the reparative powers. If overmen would but remember this they would prevent much cruelty, trouble, and loss.

Nothing can be more certain than that if a horse is over-worked for a week, his powers will be so reduced that a more than equivalent loss of work is experienced next week. On this subject Mr. Wight says in his paper:—

> What more than anything else reduces the length of life of horses is the want of proper attention by the officials and the reckless way in which they are worked. The custom of working horses extra shifts is a way of quietly murdering them. Extra shifts

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cannot be worked without great injury. and they should never be adopted except in cases of emergency, yet it has become a habit to do so in many collieries; however, to say nothing of the inhumanity of the practice, it does not pay. An extra horse standing idle in the stable would pay the colliery owner much better than allowing a single horse to be worked overtime systematically.

The writer's first introduction to nearly every colliery with which he is connected has been brought about by an excessive loss in the horse establishment—a loss of horse flesh and of work. In every case the cause of this has been either under-feeding or under-horsing, and the balance has not been restored by the most careful attention till hundreds of pounds have been lost. The reduction of the out-put of coal has frequently been enormous, and the loss from this cause alone was more than twenty times the cost of the additional horse-power or food requisite to have prevented it.

In practice, the writer's frequently expressed desire for a full complement of horses on an establishment has earned for him the character of over-horsing the pits at which he attended. This character, however, is only given by men who have no practical experience of the results of horse management. Not unfrequently, too, has it been stated that he deliberately adopted this plan that he might show a favourable balance sheet of feeding; in other words, accused of overstocking the pits with horses that the amount of food required might be reduced, and thus show a spurious economy.

It has often been suggested to the writer that he should give an opportunity to those who disagree with him respecting the management of horses openly to state their views, and he has written this paper in the hope that in the discussion all possible objections may be urged against his treatment of horses, so that he may have an opportunity of answering them. It is a subject upon which much diversity of opinion must exist, and the writer hopes that the discussion may not prove the least valuable portion of this notice, and that his views, strengthened as they are by a long experience obtained from the great number of animals which have been under his care, will be still further confirmed by the observations of all those colliery managers who have given the subject the consideration it deserves.

With respect to the information given in the Appendix, it may be as well to note that the whole of the information therein is taken from the colliery books, and that every figure has been verified by the respective officials of the collieries.

An examination of the tables will show how very much alike is the cost of each animal, when the cost of the provender is taken at the same collieries; the widest margin of difference being less than ½d. a day per

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horse; and this, although there is a considerable variation of the proportion of the different kinds of grain at the different collieries, often caused by the high prices charged for hay and oats off the owners' farms, which are always higher than the prices offered by merchants.

The Mickley report is especially deserving of attention, as it shows that horses can be kept up to their work and in good health where no oats have been used.

The report from Bearpark is also especially worth consideration, seeing that this colliery is under the special consideration of the President.

The following statement shows the cost of upholding a stud of horses for twelve years.

TABULAR STATEMENT SHOWING THE NUMBER OF HORSES AND PONIES BOUGHT, SOLD, DIED, KILLED, AND DESTROYED AT BACKWORTH AND WEST CRAMLINGTON COLLIERIES DURING THE TWELVE YEARS ENDING 31ST DECEMBER. 1881.

YEARS.	BOUGHT.		SOLD.		DIED.		KILLED.		DESTROYED FROM OLD AGE.	
	Horses.	Ponies.	Horses.	Ponies.	Horses.	Ponies.	Horses.	Ponies.	Horses.	Ponies.
1870	...	...	2	15	...	1	1	1	2	2
1871	2	3	3	4	1	1	..	3	1	...
1872	1	30	...	4	2	5	1	6	...	3
1873	2	9	3	6	2	6	1	2	...	...
1874	2	35	5	5	...	...	...	5	...	1
1875	4	35	4	7	2	1	1	2	1	2
1876	4	16	4	3	1	2	2	4	2	...
1877	1	20	2	9	...	1	...	5	...	4
1878	3	20	4	7	...	3	...	3	...	1
1879	5	24	...	5	...	1	...	5	1	1
1880	11	15	3	4	...	5	...	3	...	1
1881	2	23	9	12	2	2	...	7	1	1
Totals ...	37	230	39	81	10	28	6	46	8	16

	£	s.	d.
Total cost for new horses and ponies for twelve years ...	5,080	2	6
Less for horses and ponies sold do. ...	1,040	12	0
	£4,039	10	6

Equal to £336 12s. 6½d. per annum for upholding the stud, or £1 18s. per head deterioration on an average of 177 horses and ponies.

Six years out of the twelve years no horse died from disease; six years out of the twelve years no pony died from disease. Twelve horses and ponies are still in the pits that have been down from fifteen to eighteen years, and a black horse called "Star" has been twenty-two years underground.

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Colliery.	Kind of Food.	Quantity of Food.	Approximate average price of Food.	Total Cost.	No. of Horses.	Cost per Horse in 1881.	Kind of Food.	Quantity of Food.	Approximate average price of Food in 1881.	Total Cost.	No. of Horses.	Cost per Horse.	Differ'nce in favour of Mixed Food.	Remarks.
			s. d.	£ s. d.		£ s. d.			s. d.	£ s. d.		£ s. d.	£ s. d.	
SOUTH HETTON AND MURTON.	Hay	281t. 10c. 1q.	73 3 per ton..	1,101 15 4	281	23 10 7¼	Hay	587t. 18c. 2q.	78 3 per ton..	2,300 5 0	134	43 12 5½	20 1 10	The price of hay has been only half the average of that in Newcastle market, due to the large stock bought in 1879 and 1880 at low prices. Health of stud has been excellent, which is the more satisfactory seeing that "influenza fever" has been more prevalent in the North of England than for a quarter of a century.
	Oats	4,922 bolls ..	6 0¼ per boll	1,424 19 1			Oats	10,452 bolls..	6 0¼ per boll	3,146 9 9				
	Peas	1,793 ,, ..	9 2 ,, ..	823 7 1			Green land, bran, beans, &c. ..	..	..	399 0 0				
	Beans	1,213 ,, ..	9 1½ ,, ..	554 10 1										
	Maize	6,625 ,, ..	6 9 ,, ..	2,234 19 11										
	Barley	290½ ,, ..	7 3½ ,, ..	105 15 0										
	Bran	600 stones..	0 8½ pr. stone	22 0 8										
	Linseed	35 ,, ..	2 2½ ,, ..	3 17 11										
	Green food and grass land ..	..	..	281 0 0										
				6,612 5 1			Cost in 1849 at 1881 prices			5,845 14 9				
RYHOPE.	Hay	257t. 15c. 0q.	85 0¼ per ton..	1,096 4 3	307	22 16 0	Hay	170t. 17c. 0q.	85 0 per ton..	726 2 3	85	42 8 11	19 12 11	Health and condition have been exceptionally good, and losses lower than any year since 1861. Slight attacks of "influenza fever" have twice visited the stud, and each time only a few animals were laid off work and no fatal cases occurred. Although grain was dearer than in 1881, by buying in large quantities the cost per horse was only increased by 1s. 7d. during the year.
	Oats	4,752 bolls ..	6 0¼ per boll	1,439 1 9			Oats	8,122 bolls ..	6 0¼ per boll	2,461 19 7				
	Beans	752 ,, ..	9 0 ,, ..	338 8 0			Bran	7½ tons ..	5 10¼ per cwt.	44 1 3				
	Barley	92 ,, ..	7 6 ,, ..	34 10 0			Grass land ..	..	..	373 0 0				
	Peas	1,872 ,, ..	9 2¼ ,, ..	862 10 4			Linseed ..	28 stones..	2 0 per stone	2 16 0				
	Maize	8,416 ,, ..	6 8¼ ,, ..	2,834 9 11										
	Bran	357 cwts. ..	5 10¼ per cwt.	104 19 0										
	Linseed	57 stones..	2 0 per stone	5 12 10										
	Green food and grass land ..	..	..	284 0 0										
				6,999 16 1			Cost in 1861 at 1881 prices			3,607 19 1				
HASWELL AND SHOTTON.	Hay	133t. 4c. 0q...	80 0 per ton..	532 16 0	255	21 18 9½	Hay	326t. 1c. 2q...	80 0 per ton..	1,304 6 0	219	28 7 9½	6 9 0	Health of stud satisfactory. "Influenza fever," in a mild form, appeared for a short time, but caused no loss. That the saving is less here than at Ryhope is due to the fact that the system of mixed food and cut hay had been partially in use before 1876.
	Oats	5,403 bolls ..	6 0 per boll..	1,620 18 0			Oats	12,085 bolls..	6 0 per boll..	3,625 10 0				
	Maize	6,576 ,, ..	6 5½ ,, ..	2,123 10 0			Barley	170 ,, ..	8 0 ,, ..	68 0 0				
	Peas and beans..	2,396 ,, ..	9 2½ ,, ..	1,103 3 2			Maize	2,088 ,, ..	6 5½ ,, ..	674 5 0				
	Barley	148 ,, ..	8s. for col. farms	66 12 0			Beans	553 ,, ..	9 2½ ,, ..	254 12 3				
	Bran	1,208 stones..	0 9 per stone	45 6 0			Bran	4,126 stones	0 9 per stone	154 14 6				
	Linseed	42 ,, ..	2 6 ,, ..	5 5 0			Green food ..	..	..	134 2 0				
	Green food and grass land ..	..	..	96 17 6										
				5,594 7 8			Cost in 1876 at 1881 prices			6,215 9 9				
CASTLE EDEN.	Hay	102t. 2c. 0q...	110 0 per ton..	561 11 0	120	20 9 4	Hay	151t. 19c. 0q.	110 0 per ton..	835 14 6	85	33 0 3½	12 10 11½	Health of stud good; much better than in 1880. "Influenza fever" did not attack the underground ponies, and only a few new ones had it in a mild form, but no loss occurred. Although food was high in price during the latter part of the year, by buying in large quantities the cost per horse was kept within satisfactory limits.
	Oats	1,155½ bolls ..	6 6¼ per boll	377 18 10			Oats	5,048 bolls ..	6 6¼ per boll	1,651 2 4				
	Peas and Beans..	812½ ,, ..	9 2½ ,, ..	374 1 9			Barley	50 ,, ..	7 0 ,, ..	17 10 0				
	Maize	2,838½ ,, ..	6 9½ ,, ..	960 19 0			Bran	6 tons ..	120 0 per ton..	36 0 0				
	Bran	43 cwts. ..	6 0 per cwt.	12 18 0			Green food and pasturage ..	..	..	265 17 6				
	Linseed	20 stones..	2 0 per stone	2 0 0										
	Green food and grass land ..	..	..	168 10 6			Cost in 1875 at 1881 prices			2,806 4 4				
				2,457 19 1										

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Colliery.	Kind of Food.	Quantity of Food.	Approximate average price of Food.	Total Cost.	No. of Horses.	Cost per Horse in 1881.	Kind of Food.	Quantity of Food.	Approximate average price of Food in 1881.	Total Cost.	No. of Horses.	Cost per Horse.	Differ'nce in favour of Mixed Food.	Remarks
			s. d.	£ s. d.		£ s. d.			s. d.	£ s. d.		£ s. d.	£ s. d.	
EAST HETTON.	Hay	76t. 5c. 2q. ..	82 3 per ton..	313 16 10	57	23 16 5	Hay	201t. 16c. 2q.	82 3 per ton..	830 0 9	54	39 8 4½	15 11 11½	Health of stud has been good and accidents below the average. Total saving per horse rather less than usual, owing to fewer having been kept.
	Oats	1,089 bolls ..	5 8 per boll..	302 17 8			Oats	4,212 bolls ..	5 8 per boll	1,193 8 0				
	Peas and beans..	438	9 2½	202 2 4			Green food ..	..	..	105 5 0				
	Maize	1,447	6 9	488 7 3										
	Bran	48 stones..	0 9 per stone	1 16 0				Cost in 1861 at 1881 prices		2,128 13 9				
	Linseed	6	2 0	0 12 0										
	Green food ..	..	..	48 2 6										
				1,357 14 7										
TRIMDON GRANGE.	Hay	53t. 1c. 0q. ..	71 3 per ton..	188 16 10	45	25 1 10	Hay	54t. 18c. 2q...	71 3 per ton..	195 12 3	21	30 15 0	5 13 2	See remarks under East Hetton.
	Oats	1,083 bolls ..	5 8 per boll..	306 17 0			Oats	1,490 bolls ..	5 8 per boll..	402 6 8				
	Peas and beans..	431	9 2½	198 17 9			Green food ..	..	..	47 15 6				
	Maize	1,204	6 9	406 7 0										
	Bran	54 stones..	0 9 per stone	2 0 6				Cost in 1851 at 1881 prices		645 14 5				
	Linseed	12	2 0	1 4 0										
	Green food ..	..	..	25 0 0										
				1,129 3 1										
BRANCEPETH AND BRANDON.	Hay	87t 8c. 1q. ..	102 6 per ton..	446 0 0	167	21 5 8½	Hay	302t. 13c. 1q.	102 6 per ton..	1,551 2 10	207	34 1 5	12 15 8½	Health of stud good and losses only one-third of those in 1869, viz., 7 as against 19. One horse and one pony died from disease in pit, two ponies at bank from cold, or 2 per cent. of the animals under special treatment. Other three cases were mares, out of a stud of 15 on the farm, showing a loss of 20 per cent. of those not under special treatment.
	Oats	2,144 bolls ..	6 0½ per boll	645 8 8			Oats	14,213 bolls..	6 0½ per boll	4,263 18 0				
	Peas and beans.	1,987½	9 2	910 5 10			Beans and peas..	1,189	9 2	549 19 0				
	Maize	4,314½	6 6	1,343 11 0			Barley	112½	6 0	36 11 3				
	Bran	1,286 stones..	0 8½ pr. stone	46 17 8			Bran	8,858 stones..	0 8½ pr. stone	322 19 1				
	Linseed	79	2 3	8 17 3			Green food and Linseed ..	..	..	338 4 0				
	Green food ..	..	..	132 0 0										
	Straw	7t. 5c. 3q. ..	60 0 per ton..	21 17 3										
				3,554 17 8				Cost in 1869 at 1881 prices		7,062 14 2				
BEARPARK.	Hay	42t. 2c. 1qr ..	70 0 per ton..	117 7 11	37	21 1 10	..	..	..	..		..	..	Health and condition of stud good; no loss from disease for the last four years.
	Oats	581 bolls ..	6 0 per boll..	175 8 10										
	Peas	303	9 3	141 7 8										
	Maize	860	6 10	296 17 11										
	Green food ..	..	..	19 10 0										
				750 12 4										
BACKWORTH AND WEST CRAMLINGTON.	Hay	120t. 5c. 1q...	91 2 per ton..	548 3 10	140	22 19 0	Hay	305 tons ..	91 2 per ton..	1,390 5 10	110	32 9 4½	9 11 4½	Health and condition of stud good; scarcely affected by epidemic of "influenza fever" raging in the neighbourhood; only a few took it, and no loss occurred. Average deaths from disease only 1 per annum, notwithstanding increased speed ponies travel to get the work out since reduction of hours.
	Oats	2,023 bolls ..	6 0½ per boll	613 4 5			Oats	3,719 bolls ..	6 0½ per boll	1,127 6 5				
	Beans	932½	10 4½	484 16 8			Beans	1,327	10 4½	689 15 3				
	Peas	59	9 2½	27 9 0			Barley	239	8 0	95 12 0				
	Maize	3,502½	6 11½	1,218 11 7			Bran	281 cwts. ..	5 6 per cwt..	77 5 6				
	Linseed	5c 2q. 10lbs.	21 0 per cwt.	5 17 4			Linseed	1½	21 0	1 11 6				
	Straw	6t. 12c. 2q...	91 2 per ton..	30 3 11			Grass	..	..	189 15 0				
	Grass & grn. food	..	..	278 0 0										
				3,206 6 9				Cost in 1862 at 1881 prices		3,571 11 6				

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Colliery.	Kind of Food.	Quantity of Food.	Approximate average price of Food.	Total Cost.	No. of Horses.	Cost per Horse in 1881.	Kind of Food.	Quantity of Food.	Approximate average price of Food in 1881.	Total Cost.	No. of Horses.	Cost per Horse.	Differ'nce in favour of Mixed Food.	Remarks.
			s. d.	£ s. d.		£ s. d.			s. d.	£ s. d.		£ s. d.	£ s. d.	
MICKLEY.	Hay	140t. 5c. 1q...	74 9 per ton..	524 5 4	131	22 18 8½	Hay	291t. 16c. 0q.	74 9 per ton.	1,090 12 3	111	38 2 3½	15 3 7½	Health and condition of stud excellent. No horse has died either at the farm or collieries from disease or accident for more than two years, and none from disease at Prudhoe for 5½ years. No oats have been used in either of the three collieries for five years, yet no horses have worked harder or been in better health.
	Peas	1,272 bolls ..	9 1½ per boll	579 16 9			Oats	8,372 bolls ..	6 10 per boll..	2,860 8 8				
	Beans	600 ,, ..	9 0 ,, ..	270 0 0			Barley	3 ,, ..	7 0 ,, ..	1 1 0				
	Maize	4,706 ,, ..	6 8½ ,, ..	1,581 15 6			Maize	384 ,, ..	6 8½ ,, ..	128 16 0				
	Bran	3 sacks ..	6 10 per sack	1 0 6			Bran and linseed ..	..	..	150 0 0				
	Linseed	10 stones..	2 0 per stone	1 0 0										
	Grass land and green food ..	..	..	46 10 0				Cost in 1874 at 1881 prices		4,230 17 11				
				3,004 8 1										
SEATON DELAVAL.	Hay	182 tons ..	90 0 per ton..	819 0 0	169	24 6 3	Hay	520 stones ..	0 6½ pr. stone	14 12 6	..	40 8 2	16 1 11	"Influenza fever" caused great losses in the Forster and Richard Pits; in the old pit only one animal had the disease. The cases were all of a most malignant type.
	Oats	3,090 bolls ..	6 3 per boll..	965 12 0			Oats	75 bolls ..	6 3 per boll..	24 7 6				
	Peas and beans..	1,595 ,, ..	9 5½ ,, ..	749 15 1			Green food ..	..	..	1 8 2				
	Maize	4,167 ,, ..	7 0 ,, ..	1,460 2 0										
	Barley	24 ,, ..	8 0 ,, ..	9 12 0				Cost in 1854 at 1881 prices		40 8 2				
	Bran	..	..	10 11 0										
	Green food ..	..	..	92 0 0										
				4,106 12 1										
BEDLINGTON.	Hay	294t. 7c. 0q...	90 0 per ton..	1,348 11 6	253	22 12 7½	Hay	466 tons ..	90 0 per ton..	2,097 0 0	130	37 15 8	15 3 0½	Health and condition of stud good; only one horse and three ponies died from disease, and two ponies from accidents. Through taking the precaution of not sending newly bought animals down the pit till 14 days or so after, the prevailing epidemic known as "pink eye" or "influenza fever" has been avoided altogether.
	Oats	2,556 bolls ..	5 11½ per boll	758 16 3			Oats	8,680 bolls ..	5 11½ per boll	2,576 17 8				
	Peas	1,573 ,, ..	9 3 ,, ..	727 10 0			Bran	2t. 12c. 0q. ..	120 0 per ton..	15 12 0				
	Beans	500 ,, ..	9 8½ ,, ..	242 17 4			Grass land ..	..	..	222 5 0				
	Maize	6,480 ,, ..	6 10½ ,, ..	2,227 10 0										
	Bran	98 cwts. ..	6 0 per cwt..	29 8 0				Cost in 1861 at 1881 prices		4,911 14 8				
	Linseed	22 stones ..	2 6 per stone	2 15 0										
	Green food and grass land ..	..	..	388 12 8										
				5,726 0 9										
NORTH SEATON.	Hay	32t. 10c. 3q...	90 5 per ton..	147 0 8	39	23 4 4	Hay	170t. 6c. 0q...	90 5 per ton..	769 17 10	52	44 2 5½	20 18 1½	Health and condition of stud has been very good, and deaths from disease and accidents below the average. The prevailing "epizootic" disease has not affected the animals, except in the case of fresh arrivals, but no case proved fatal.
	Oats	544 bolls ..	6 5 per boll..	174 10 8			Oats	4,680 bolls ..	6 5 per boll..	1,501 10 0				
	Peas	458 ,, ..	9 2½ ,, ..	210 7 10			Bran and grass..	..	..	23 0 0				
	Maize	1,046 ,, ..	6 9½ ,, ..	354 2 3										
	Bran	4 cwts. ..	7 0 per cwt..	1 8 0				Cost in 1861 at 1881 prices		2,294 7 10				
	Green food ..	..	..	18 0 0										
				905 9 5										
COWPEN AND CAMBOIS.	Hay	175t. 15c. 2q.	90 5 per ton..	794 12 8	175	23 9 6½	Hay	242t. 1c. 0q...	90 5 per ton..	1,094 5 4	108	37 18 5½	14 8 11	See remarks for North Seaton.
	Oats	2,783 bolls ..	6 5 per boll..	892 17 7			Oats	7,723 bolls ..	6 5 per boll..	2,477 15 11				
	Peas	1,795 ,, ..	9 2½ ,, ..	824 11 7			Beans and peas..	525 ,, ..	9 2½ ,, ..	241 3 5				
	Maize	4,530 ,, ..	6 9½ ,, ..	1,533 11 10			Bran	18t. 4c. 0q. ..	140 0 per ton..	127 8 0				
	Bran	19 cwts ..	7 0 per cwt..	6 13 0			Grass land and green food ..	..	..	155 0 0				
	Green food ..	..	..	56 0 0										
				4,108 6 8				Cost in 1861 at 1881 prices		4,095 12 8				

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Colliery.	Kind of Food.	Quantity of Food.	Approximate average price of Food.	Total Cost.	No. of Horses.	Cost per Horse in 1881.	Kind of Food.	Quantity of Food.	Approximate average price of Food in 1881.	Total Cost.	No. of Horses.	Cost per Horse.	Differ'nce in favour of Mixed Food.	Remarks.
			s. d.	£ s. d.		£ s. d.			s. d.	£ s. d.		£ s. d.	£ s. d.	
EAST HOLYWELL.	Corn, &c.	..	..	1,081 16 6	45	26 5 0	Hay	140 tons ..	9½ 2 per ton..	638 3 4	35	43 7 9½	17 2 9½	Health and condition good. Saving more than at Backworth, where special feeding had been partially introduced before the new system had been formally introduced.
	Green food and grass land ..	..	..	99 11 6			Oats	2,733 bolls ..	6 0½ per boll	828 8 10				
							Gr. fd. & grass lnd.	..	..	52 0 0				
				1,181 8 0					Cost in 1861 at 1881 prices	1,518 12 2				
STELLA AND TOWNELEY.	Hay	138t. 17c. 3q.	106 6 per ton..	739 11 9	52	28 18 7½	Hay	102t. 6c. 0q...	106 6 per ton..	544 15 0	31	45 15 6	16 16 10½	Health and condition good. "Influenza" did not affect the stud. No deaths at either of the three pits. Extra cost of the horses attributed to the hay not having been cut.
	Oats	590 bolls ..	6 5½ per boll	190 17 6			Oats	2,530½ bolls..	6 5½ per boll	819 15 6				
	Peas and beans..	531 ,, ..	9 5½ ,, ..	251 0 0			Green food and grass land ..	..	..	55 0 0				
	Maize	1,850 ,, ..	6 7½ ,, ..	612 10 0										
	Barley	70 ,,	6 9 ,, ..	23 12 6					Cost in 1869 at 1881 prices	1 419 10 6				
	Bran	2 tons ..	136 3 per ton..	13 12 6										
	Linseed	..	..	0 6 3										
	Grass land, &c..	..	..	98 3 6										
				1,929 14 0										
	Less for Provender supplied to Farms			425 5 2										
				1,504 8 10										
OUSTON.	Hay	110t. 15c. 0q.	132 0 per ton	729 8 6	113	25 7 0	Hay	267t. 4c. 2q...	132 0 per ton..	1,763 13 9	115	41 15 3	16 8 3	General health good and accidents moderate. During the autumn, when "influenza" was prevalent, only a few of the surface horses had it, and those only slightly.
	Oats	2,114 bolls ..	6 0½ per boll	639 4 10			Oats	8,061 bolls ..	6 0½ per boll	2,441 2 8				
	Peas and beans..	917 ,, ..	9 3½ ,, ..	427 6 11			Beans	184 ,, ..	9 3½ ,, ..	85 13 6				
	Barley	320 ,, ..	6 0 ,, ..	96 0 0			Maize	420 ,, ..	7 1½ ,, ..	150 1 3				
	Maize	2,230 ,, ..	7 1½ ,, ..	792 10 3			Green food ..	..	..	299 0 0				
	Bran	96 stones..	0 9½ pr. stone	3 18 0			Straw	..	..	42 0 0				
	Linseed ..	3 ,, ..	2 8 ,, ..	0 8 0			Bran	..	..	19 6 4				
	Green food and grass land ..	..	..	125 10 0					Cost in 1877 at 1881 prices	4,800 17 6				
	Straw	12t. 3c. 0q. ..	..	49 11 11										
				2,863 18 5										
WHITEHAVEN.	Hay	197t. 3c. 2q...	97 0 per ton..	956 4 0	171	29 1 0½	Hay	548t. 12c. 0q.	97 0 per ton..	2,659 14 8	178	38 16 3½	9 15 2½	Health and condition good, and the accidents in Croft, Willington, and William Pits below the average, while in Henry Pit they have been slightly above, probably owing to the heavy gradients.
	Oats	4,676½ bolls ..	6 2½ per boll	1,458 4 9			Oats	12,324 bolls .	6 2½ per boll	3,838 8 3				
	Peas	2,492 ,, ..	9 2½ ,, ..	1,150 1 3			Bran	57t. 17c. 0q...	0 9½ pr. stone	356 14 10				
	Maize	3,352 ,, ..	6 1½ ,, ..	1,029 14 10			Green food ..	..	..	54 0 0				
	Bran	2,567 stones..	0 9½ pr. stone	100 5 0										
	Green food, &c..	..	..	273 8 9					Cost in 1866 at 1881 prices	6,908 17 9				
				4,967 18 7			Difference per Horse per Year. £ s. d. 21 12 0	..	..	..		..	..	
CORPORATION HORSES.	Hay	84t. 6c. 2q. ..	90 0 per ton..	379 9 3	58	31 12 3½ or including expense of building and carriage of food, 34 9 0								Health and condition good. No horse died from disease; one had to be destroyed for broken legs; one died from injured shoulder; there were two outbreaks of "influenza," but no fatal case.
	Oats	1,148 bolls ..	5 11 per boll..	339 12 4										
	Maize	2,082 ,, ..	6 0 ,, ..	624 12 0										
	Beans	227 ,, ..	9 0 ,, ..	102 3 0										
	Peas	723 ,, ..	9 2½ ,, ..	332 8 5										
	Bran	39 sacks ..	6 0 per sack	11 14 0										
	Linseed	3 stones..	2 6 per stone	0 7 6										
	Green food ..	..	..	43 7 0										
				1,833 13 6										

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To illustrate Mr C. Hunting's paper "On the Feeding and Management of Colliery Horses."

FIG. 1.

PLAN.

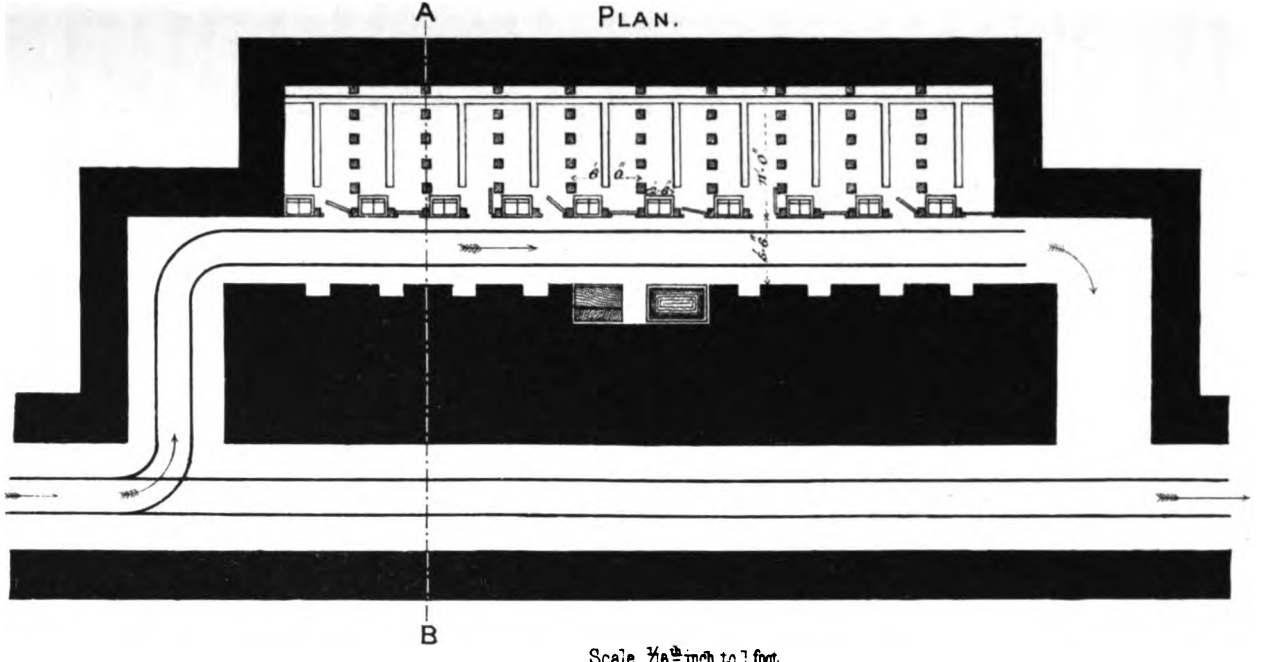

FIG. 2.

SECTION THRO' A.B. FIG. 1.

Scale 1/8th inch to 1 foot.

Andrew Reid Newcastle

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The PRESIDENT said, he had much pleasure in proposing a vote of thanks to Mr. Hunting for the paper. Although the introduction of machinery during the last thirty or forty years had greatly lessened the use of horses, the cost must still be a considerable item in the expenses at most collieries. Having for twenty years been acquainted with Mr. Hunting's system of feeding, which had given him every satisfaction, he was very glad that it had been brought before the Institute, as it was a matter of very great importance to colliery managers.

Mr. T. J. BEWICK seconded the vote of thanks; and the motion was agreed to.

Alderman WILSON (Chairman of the Town Improvement and Sanitary Committees of Newcastle Corporation) said that, as he was not a member of the Institute, he was only there through the courtesy of a member, and as he had been invited to speak on the subject he had very much pleasure in adding his testimony to the efficiency of the system of feeding which Mr. Hunting had brought before them. It was now about four years since Mr. Hunting's system was brought under his notice; and as the head of a Committee of the Corporation of Newcastle, having charge of a large stud of horses, he (Mr. Wilson) considered it his duty to bring Mr. Hunting's system before the Town Council. The Town Council authorized the Committee to enter into an engagement with Mr. Hunting to take charge of the entire stud of horses—to purchase, sell, doctor, and feed the horses belonging to the Corporation. At that time the keep of the horses cost 22s. 2d. per head per week, and during the first year of Mr. Hunting's management the cost was reduced to a little over 14s. per head per week. The result was so satisfactory that Mr. Hunting had been continued in charge of the stud. That gentleman had the greatest obstacles and difficulties to contend with when he first took charge of the Corporation horses, for he met with opposition at all points. Where there was a large number of men employed, a change of system was not very palatable; and perhaps Mr. Hunting had more than usual opposition to contend with; but he persevered, and was supported by the Committee, and the result was the Corporation stud of horses were now in the best possible condition; and, as Mr. Hunting stated, the saving amounted to £1,300 to £1,400 a year for the stud of sixty or seventy horses. He did not like to boast, but he was told the Newcastle Corporation horses would favourably compare with any stud in the country.

Mr. T. W. BENSON asked Mr. Hunting's opinion as to the economy of using seed hay or old land hay? So far as his experience went, pit horses used less old land hay, and apparently kept in quite as good condition: but horse keepers and cartmen generally spoke in favour of seed hay.

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Mr. HUNTING said, he was pleased that this question had been asked. He had arrived at the conclusion that the best old land hay was more nutritious than the best seed hay. He knew that this opinion was generally opposed by many horse men, but the only reason he could arrive at why they held that opinion was that horses eat more seed hay. The strongest evidence he could produce in favour of his views as to the value of old land hay was that of the late Mr. Cole, of Bebside. Up to the time of the reading of the author's paper on "Horse Feeding," before the Farmers' Club, that gentleman was greatly in favour of seed hay for pit horses, and instituted the following experiments for the very purpose of upsetting the author's published statement, Mr. Cole being opposed to the plan of feeding advocated. For three months he put one of his studs on old land hay and the usual quantity of corn, and another stud, at another pit, on seed hay and the same quantity of corn. At the end of three months he reversed this experiment, putting those that had been eating seed hay on to old land hay, and *vice versâ*, with the same quantity of corn in each case. The health and condition of the studs were exactly the same in both cases, and the work also, but in each case 25 per cent. more seed hay than old land hay was consumed. The great value of this experiment was in the fact that it was adopted to prove how erroneous were the author's statements, whereas it fully confirmed all that had been stated. He advised the introduction of old land hay at some collieries in the north. It was very much objected to, and a report was sent to the head viewer to the effect that, unless some alteration was made, the pit work would be stopped, because the old land hay was injuring the animals, for only two tubs instead of three of manure were sent to bank daily since its use; this of course would be accounted for in the smaller quantity of old land hay taken. The condition of the horses was, however, proved to have been in noway affected. There was no doubt that the best old land hay is more nutritious than seed hay, owing to there being less insoluble matter in the former than in the latter; but most horses prefer the seed hay, and eat more of it.

Mr. LAWRENCE said, that at some of the breweries in London there was a similar process of mixed food for horses. A friend of his, who was the partner who had charge of this department in a brewery, told him that great advantage was found by putting maize into tubs and steeping it in water for twenty-four hours. At the bottom of each tub or cask was a plug, and at the end of twenty-four hours the plugs were drawn out and the water run off; and after standing twelve hours longer in the casks, the maize was removed to granaries and watched until it sprouted to a certain point; and the maize so treated was found more nutritious than the

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maize in the form in which it is used here. At the brewery all food was cut and mixed before it was given to the horses; the green food was also mixed with the rest of the food. He remembered reading a discussion which took place at Glasgow with respect to the feeding of horses, in which it was stated that a certain proportion of locust beans was mixed with the food of the tramway horses.

Mr. HUNTING said, he knew there were some people who preferred to have maize steeped in water before using it. He believed it was this plan of using soaked maize which first led him in 1853 to reject it. The only advantage which maize could have in the state of fermentation described by Mr. Lawrence would be the converting its starchy matter into the first or second stage of sugar—half-way on to fat. There could be no doubt that it would be better to use maize so treated for the feeding of poultry, pigs, or cattle, where no muscular exertion, or very little, was required, and where the deposition of fat on animals was the great object in view. He had the greatest possible objection, however, to the use of boiled food for horses. In Scotland it used to be the custom to use boiled food for agricultural horses. Every night a large pailful was given to each horse; and the serious loss of animals which ensued from inflammatory affections of the bowels, was considered by Professor Gamgee to be almost entirely due to the use of boiled food. Those who understood the process of digestion could readily understand that a horse, coming in cold and shivering, and eating a large quantity of boiled food—a soft, pulpy mass—and filling up its time by eating hard uncut straw would have a great tendency to produce inflammation; and it was shown that the horses lost in Scotland from colic were 200 per cent. more than the number lost in England. This subject was investigated, and it was found that where the great loss of horses occurred, it was due to the use of boiled food. No amount of preparation of any kind—chopping or bruising, steaming or boiling—could add to the nutritive value of food for animals. The constituents were there. Preparation of the food might cause the more or less free passage of the indigestible portions of the food through the alimentary canal; but no process of cooking increased the nutritive value of any kind of food used by animals.

Mr. RICHARD FORSTER said, he had had experience of Mr. Hunting's system in connection with the feeding of horses at collieries. On looking at the figures given by him he found that the expense per horse at the collieries he had personally worked under this system came to about the mean average given in the paper; and if the figures were still further considered with regard to the number of tons sent out of the colliery, it

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would be found that there was not only a saving in the cost of feeding the horses, but also upon the cost per ton raised. He alluded to the cost per ton, because when this system of feeding was discussed it was sometimes said that more horses had to be used to do the same amount of work. That argument would be met if the calculations were based upon the cost per ton of output. Mr. Hunting's sole object appeared to be to alter the mixing of food as prices changed, so as to make the feeding, whilst most economical for the owners, at the same time best for the horses, by taking care always to preserve in the mixture a proper supply of nitrogenous food.

Mr. RICHD. S. JOHNSON said, that in early life he opposed Mr. Hunting, but he had since become a thorough convert to his system. He had reason to thank him for the great saving effected at the collieries he had charge of, not only in connection with the feeding of horses but also in connection with the case-book. He urged the managers of all collieries to carry out the recommendations of Mr. Hunting.

Mr. W. F. HALL endorsed the remarks made by Mr. Forster and Mr. Johnson. Mr. Hunting's system was brought under his notice in 1864, and since that time it had been pretty generally carried out. He agreed with Mr. Forster as to stating the cost per ton; and he had found in his practice that the cost per ton was not so great. The case-book was, he thought, the only means to keep evil-doers from going wrong; if it were known that the case-book came before the manager, the driving of poor animals to death would be put a stop to. Mr. Hunting was very fair in stating his case; he did not favour any one. At Ryhope there were a large number of horses heavily worked; it was perhaps what was called a warm pit, and horses took much more harm in warm than in cold pits; but the horses at Ryhope would compare favourably with horses in any coal-pits in Northumberland or Durham doing similar work, both in regard to condition and duration of efficiency, as well as economy of feeding.

Mr. T. W. BENSON asked Mr. Hunting whether he considered it any advantage to give horses the sweet-smelling condiments, which one was so often asked by agents and travellers to purchase. His own reply to such applications generally was to the effect that a horse in good condition ought not to want such compounds.

Mr. WILLIAM BOYD said, that many gentlemen might have seen in the *Times* during the last two or three months accounts of the mode of treating green food in what were called "silos." The green food was cut in the usual way in the field, and then chopped up small and put at once into pits or "silos," which were pits bricked out and lined with cement. The material was heavily pressed down with stone flags on the top. The hay and clover

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were put into these pits irrespective of weather, climate, or condition. It was stated that on the pit being opened there was a certain depreciation in the upper layers for a very small distance down, and that the remainder of the contents of the pit formed a green food equal in nutritious value to the material when it first came off the land. This system was quite new, and had not, he believed, yet been tried in the North of England. The food thus produced was called "*ensilage*."

Mr. HUNTING, in reply to Mr. Benson's question, said that, with respect to condiments or spice food, there was a "paper war" carried on for five or six weeks between himself and Messrs. Blundell and Spence and Mr. Thorley, shortly after he read a paper, twenty-five or twenty-six years ago. Condiments were never nutritious, but were beneficial only to animals out of health; just as a man, when he was shivering and cold, took a glass of hot stimulant, which in a short time would warm him. To give animals condiments or spiced food, with a view to improve their condition, was simply to throw money away. Probably Mr. Laws, of Roehampstead, had given most attention to this subject, and, after experimenting on hundreds of animals, had come to the conclusion that he would be a great loser by using condiments, even if given to him. All the greatest physicians had come round to the old dietetic system recommended by hydropathists. He was not a hydropathist, but he knew that nineteen-twentieths of the success of hydropathic treatment consisted in the adoption of absolutely perfect dietetic arrangements, only such food as the system required being permitted. If animals are constantly given either vegetable or mineral tonics or stimulants with their food, they become not only useless but ill. All healthy animals take as much food as they require and their systems can assimilate; and the food not assimilated has to be carried out at the expense of the lungs, the liver, or kidneys; the loss was threefold:—First, in paying for the food; second, in causing the animal to eat more than it could assimilate; and third, the waste of tissues in carrying off the food taken in by the animal, which was not required. In reply to Mr. Boyd's question he said ensilage had been used very largely by some Frenchmen, and also in the United States of America. He had accounts sent to him from America by men whom he knew to be able and trustworthy agriculturists, and they said ensilage was something very marvellous. Green food of all kinds, in a green state, was put into receptacles or pits, and was so pressed down as to exclude the air, and consequently prevent fermentation; and it was said that when taken out of the pit it came up to the analysis of all the nutritive juices of the grass as when put in, and that they were able to keep something like 25 per cent. more horses and cattle upon a quantity of ensilage brought out of the pits in winter than they

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would upon the same quantity dried in the field and stacked in the usual way. By another year he hoped to make an experiment with it himself; he intended to make a pit and test the matter. There could be no question whatever that there were great losses in using all kinds of grasses and cereals as dried food as against food when in the growing condition and when maturing into seed. If grass was cut three or four days before it flowered in full it would contain at least 25 per cent. less woody fibre than when ripe, and if allowed to stand until dead ripe, it would contain 50 per cent. more than when cut early. If cut soon, they got a material that contained largely the constituents which formed blood; but those constituents when formed into woody fibre, were useless as food, and were passed through the alimentary canal as refuse.

The discussion was adjourned.

The discussion on "The Description of a New Ventilating Fan," by Mr. T. J. BOWLKER, and the "Report of the Committee on Mechanical Ventilators," was resumed.

Mr. T. J. BOWLKER—At the first discussion on the subject Mr. Morison was understood to say that there was no friction in the Guibal fan because there was a partial vacuum inside, but at the next meeting this was slightly extended, and it appeared that the reason there was no friction was, that each particle of air got continually into a region of lower pressure as it went round the fan. Let it be supposed then that air, under either or both of these conditions, really is free from friction, the inevitable conclusion must be that the air traverses a mine without friction, for it certainly satisfies both of these conditions; since, if a pipe be put down from the surface to any part of the mine a partial vacuum would be found which would gradually increase as the upcast shaft was approached, so that the air as it went along would be continually getting into a region of less pressure, just as the air inside the Guibal casing does, so that if Mr. Morison's theory were true it would have to be admitted that there was also no friction of the air in the mine. Mr. Morison went on to say that having two or more outlets instead of one would cause the fan to lose the potential energy saved in the Guibal from the tangential force; to this it may be alleged that it is only necessary to point to the facts of the case, for the water-gauge shows conclusively that the three-outlet fan saves more of the tangential energy than the Guibal. If there were an outlet at every foot of the circumference, as Mr. Morison

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suggested, still more of the tangential energy would be saved, but not enough to pay for the expense of having say 30 outlets instead of three. Mr. Steavenson furnished a translation of a portion of a paper by MM. Pernolet and Aguillon, which, however, as it did not seem to bear on the particular phase of the matter under discussion need not be further noticed. Mr. Cochrane, in his remarks at the last discussion, considered that the comparison between the 8 feet 6 inches Bowlker and Watson fan and the 45 feet Guibal fan was unfair, and this he went on to say was owing to $\frac{V^2}{h}$, or the square of the volume of air divided by the water-gauge, being so much smaller in the ventilation with the 8 feet 6 inches fan, than in the ventilation with the Guibal; from which remarks it must of course be inferred that the Guibal fan will give worse results as the square of the volume increases, that is as the volume of the air dealt with increases so long as the water-gauge remains the same. This seems to be an admission in no way calculated to add to the reputation of the Guibal as a ventilator adapted for dealing with large quantities of air; for it appears that if with a Guibal getting 30,000 cubic feet of air at a given water-gauge a certain useful effect is obtained, a poorer percentage of useful effect may be expected when a Guibal gets 150,000 cubic feet of air per minute with the same water-gauge. This is a defect in the Guibal which it must be confessed had not been brought before his notice before. After having learned that the Guibal gives its best results when $\frac{V^2}{h}$ is small, one is rather astonished to have as an example of a Guibal with a large useful effect a fan alluded to in which $\frac{V^2}{h}$ is enormously large, very much larger than in the experiment with the Rockingham fan, where $\frac{V^2}{h}$ was considered too large. There is some mystery about this $\frac{V^2}{h}$ which it is difficult to understand, and it is quite certain that $\frac{V^2}{h}$ affects the Bowlker and Watson fan in a very different manner, for with it as $\frac{V^2}{h}$ is increased the useful effect is increased also. Mr. Cochrane's observation is so far right that the comparison between the 45 feet Guibal and the 8 feet 6 inches Bowlker and Watson fan was unfair, and unfair to the latter fan. Mr. Cochrane also says that the experiments in his (Mr. Bowlker's) paper do not show any advantage of this fan over the Guibal, but to this he demurred. The useful effect of the Rockingham Guibal is stated in

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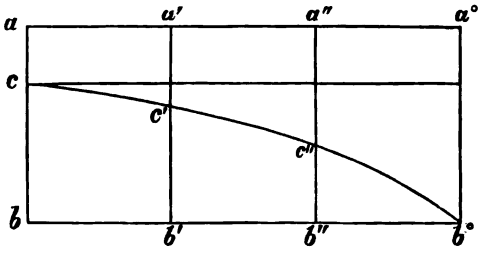
the paper to be from 40 to 50 per cent. The experiment with the Guibal which gave 57 per cent. of useful effect was an experiment under entirely artificial conditions, the separation doors being opened, and therefore, it would be unfair to compare the useful effect obtained in such a case with that obtained in the experiments with the 8 feet 6 inches fan which were under the normal conditions of ventilation. The other experiment which Mr. Cochrane referred to and asked why it was not taken was also under artificial conditions and did not give such a good useful effect. There is something else in the Guibal, which is considered one of its great advantages, and that is the shutter, and this, too, seems to be somewhat mysterious in its action. This is sometimes referred to, almost as if it were some source of power to help the fan when it got into difficulties. He confessed that he understood very little about the benefits of the shutter; but so far as his experience went, it seemed to act the part of scapegoat to all the shortcomings of the Guibal fan; it always seems, unfortunately, to be in the wrong place, and, therefore, a fan in which it was dispensed with would probably be desirable. This, however, is certain, that the shutter will not prevent any of that great loss occasioned by the air friction in the casing; indeed lowering the shutter down, as it increases the rubbing surface, will increase that friction slightly, therefore all it can do, if it does anything, will be to prevent loss through re-entry, and so on. The varied proportion of the useful effect of the Guibal fan, supposing the shutter to act perfectly, to the power used might be illustrated by the following diagram :—Let $a\ b$ represent the power spent on ventilation and air friction when the utmost useful effect $c\ b$ was obtained, and let $c\ b^o$ in a curve representing the varied effect from $c\ b$ where 4,000 feet per revolution pass to b^o where no air passes, in which latter case the whole of the power used $a^o b^o$ will be thrown away, and at any other position $a'\ a''$ the relation of the total power to the useful effect will be as $a'\ b'$ to $c'\ b'$, and $a''\ b''$ to $c''\ b''$ respectively; from which diagram it is evident that the Guibal is, in spite of the shutter, ill adapted for varying conditions of ventilation.



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Mr. Cochrane admits the fact of there being friction in the Guibal casing, but considers it probable that he (Mr. Bowlker) had made a mistake in the co-efficient; this is quite likely, although every care to prevent mistakes was taken; but as all previous experimenters have obtained higher co-efficients (that of Peclet being about ten times as great), it is rather likely that if there be a mistake, the co-efficient, as given in the paper, is too small rather than too large. But the members of this Institute are not asked to believe in any experiments except their own, and he (Mr. Bowlker) would only be too glad if the members would make their own experiments to test the results given; for although it may be a matter of perfect indifference to most whether this co-efficient is right or wrong so far as it affected his theory as to the friction of air in fans, yet surely it is desirable for other reasons to ascertain the true value of the co-efficient of friction of air against brick-work. Mr. Bowlker concluded by stating that Mr. Cochrane wished an experiment had been tried with this fan at the same periphery speed as in the experiment with the Rockingham Guibal, when the Guibal gave 37 per cent. of useful effect. He would see that this had been done by Mr. Lindsay, and this fan has been found to give 50 per cent. at that low speed; and he was much obliged to Mr. Daglish for his kindness for having had this fan experimented on in the same way as the other types of fan had been by the Committee.

Mr. D. P. Morison said that, after such a long dissertation against the Guibal fan, he felt it somewhat difficult to make a suitable answer, without time for careful analysis of the numerous points raised. The concluding portion of Mr. Bowlker's remarks was the most practical, where he urged that some experiments should be made with the fan, and compared with the results obtained from a Guibal fan of similar size, and as far as possible, under the same conditions. He (Mr. Morison) was sure, if such a comparison were made, very probably the result of the Guibal fan would be found to maintain its usual prominent position, and Mr. Bowlker's would perhaps not be very far off. It was impossible to answer *seriatim* the remarks and figures of Mr. Bowlker but he would take two or three of them. It occurred to him that Mr. Bowlker had not drawn the diagram showing the loss of power due to friction in the casing as he should have drawn it. The diagram, as drawn, would actually represent the power expended on the volume of air itself and not that on the friction. Until the diagram was properly put before the Institute he could scarcely understand it.

Mr. Bowlker said, that $a\ b$ on the diagram represented the proportionate total power expended for any given useful effect $c\ b$; the space $a\ c$

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at the top represented the proportion of the power spent in friction of the air, compared with the space $c\ b$ at the bottom, representing the useful effect or power spent on ventilation; that $a'\ c'$ represented the proportion lost in friction when $c'\ b'$ represented the useful effect; and that $a''\ c''$ was the friction due to $c''\ b''$, and so on till no useful effect was obtained, when $a^o\ b^o$, the power exerted in using the fan, was all thrown away, as no air was passed.

Mr. MORISON said, that from the diagram it might be understood that the Guibal expended as much power in passing no air at all as it did in passing 4,000 feet per minute. Further, with regard to the shutter, it was of so much importance that, under certain conditions, it would make a difference of 50 per cent. in the volume of air discharged by the fan. When the shutter was too far open there was sometimes a re-entry, due to too much area of outlet; and when the shutter was too far down, there was throttling. As to Mr. Cochrane's remarks on $\frac{V^2}{h}$, Mr. Bowlker had exactly reversed their meaning. The larger V^2 is in proportion to h, the better is the result by the Guibal and by any other system. Wherever V^2 is large and h is small, either the Guibal or Bowlker, or any other fan, would give the best results. Mr. Bowlker did not utilize the tangential velocity; the tangential velocity could not be restored in his system by the increase of depression or water-gauge produced up to the point of discharge. He thought any comparison of the friction of the air in the mine itself, as compared with imaginary friction in the casing was erroneous, and would hardly be borne out in either the Guibal or any other system.

Mr. J. A. G. ROSS said, that so far as his experiments had shown, the greater velocity any fluid had in passing through passages the greater was the friction, and that to in a very much greater ratio than simply that due to the proportionate velocity, and therefore he thought that the diagram was wrong, as it seemed to indicate that when small quantities of air passed, which of course meant less velocity, the greater was the amount absorbed.

Mr. BOWLKER was afraid Mr. Ross scarcely understood what the diagram was intended to show, and, therefore, the conclusions drawn from it and his experiments hardly bore on the point at issue. In the Guibal fan, going round at a certain speed, the friction of the air against the casing would, as long as it went at that speed, be the same whatever the quantity of air was passing through the fan. If the fan was discharging very little air and doing very little work in ventilating the mine, this

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friction of the air would occupy a very much larger percentage of the whole work done. When the fan was entirely closed and discharging no air at all, all the work would be represented by the vertical line $a^o\ b^o$ at the end of the diagram, which occupied the whole of the space. He was glad to learn from Mr. Morison that the Guibal was no exception to the ordinary fan, and that as $\frac{V^2}{h}$ increased, the Guibal fan continued to give better results. That was not what Mr. Cochrane said, comparing the 8-feet 6-inches fan and the 45-feet Guibal fan. Mr. Morison said that his (Mr. Bowlker's) fan did not utilize any of the tangential velocity at all; and he would like to ask Mr. Morison how it was that it gave such a high water-gauge? It was quite impossible, on mathematical principles, to get a water-gauge equal to this fan if there was no tangential velocity utilized. In this fan there was as much of the tangential velocity utilized as in the Guibal fan.

The discussion then closed.

The following "Remarks by M. Er. Mallard on Mr. Lindsay Wood's Experiments showing the Pressure of Gas in the solid Coal," translated by Mr. M. WALTON BROWN, were taken as read :—

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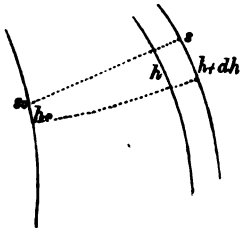
REMARKS ON MR. LINDSAY WOOD'S "EXPERIMENTS SHOWING THE PRESSURE OF GAS IN THE SOLID COAL," BY MR. E. MALLARD.*

TRANSLATED BY M. WALTON BROWN.

MR. MALLARD gives an abstract of those parts of Mr. Lindsay Wood's paper describing the mode of making the experiments and the results obtained therefrom, and remarks that Mr. Wood has modestly confined himself to drawing the attention of his readers to the possibility of the maximum pressure varying as the square root of the depth of the hole. He then states that he draws another conclusion from the results of the experiments. The following is a translation of his reasons for this assertion :—

Among the various conjectures that have been made as to the origin of the existence of gas in coal, the most simple is to suppose that the gas permeates the coal in the same way as water permeates a porous stratum, and that a gassy seam is a gaseous horizon, in the same manner as a bed of sandstone is an aquiferous horizon. By this hypothesis, whatever has been, in the beginning, the relation that has united the formation of the fire-damp with that of the coal, there would be, between the gas and the coal, an independence as complete as that which exists between the water and the sandstone of the watery horizon.

If this supposition be correct, the motion of gas through coal must follow the same laws as those which regulate the motion of water in an aquiferous stratum. But the distribution of the pressure in the mass of the coal, from the open surface inwards, evidently depends upon the manner in which the gas distributes itself in this mass. One would suppose, therefore, that the experiments made by Mr. Wood would allow the truth or the error of this theory to be ascertained.



Suppose that the coal exposes in s_0 an open surface in contact with an atmosphere, in which the fire-damp has a pressure h_0, inferior to the maximum pressure H of the gas in the coal; fire-damp escapes continuously by this surface, and, at any moment, the pressure of the gas in the interior of the coal increases, beginning from s_0, from h_0 to H.

* From the Annales des Mines. Series VIII., Vol. I., pp. 530-551.

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It can be assumed that the mass of the coal is traversed by a system of surfaces or isobars of equal pressure.

Take at s_0 an infinitely small surface, and produce from this surface normal lines at each point to the isobaric surfaces passed through. In the kind of tube thus formed take a piece contained between two infinitely approached isobaric surfaces corresponding to pressures h and $h + dh$. Let dr be the distance between the two surfaces, s and $s + ds$ the areas described by the tube upon each of them.

Between the sections s and $s + ds$ there will be a flow of gas, and this flow is in the direction of the section upon which the least pressure is exerted. The weight of gas which, in the unit of time, flows in this manner from the surface $s + ds$ to the surface s, along the pipe dr, is necessarily proportional to dh.

This weight can be represented by

$$asdh,$$

a being a co-efficient which measures the permeability of the coal to gas, and which is so much the greater as the permeability is greater.

The weight of gas which traverses the unit of distance in the unit of time is equal to

$$as\,\frac{dh}{dr}.$$

If k represents the delivery of gas through the unit of surface,

$$ks = as\,\frac{dh}{dr}.$$

This is, in fact, the law which has been experimentally found by Darcy to represent the flow of water filtering through a porous stratum.

The flow k varies at every moment, but if the phenomenon at the end of a given time be considered, the variations of k with the time are very small, and k can be considered at any instant as practically constant.

Let s_0 be the area defined on the surface S by the orthogonal tube, the flow through the surface s_0 is $k_0 s_0$, k_0 being the flow per unit of surface through the surface S at the point considered, then, on account of the approached permanence of the motion,

$$k_0 s_0 = as\,\frac{dh}{dr}. \tag{1}$$

This differential equation discovers, after integration, the law which, at the instant considered, connects h to r, that is the law of the distribution of the pressure in the mass of the coal.

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It may be mentioned that this theory is exactly that which is applied to a mass having an initial temperature H, and which is supposed to be cooled by an open surface plunged into an enclosure of the temperature h_o. The co-efficient a will then be the co-efficient of the conductivity of heat of the mass. The quantities of heat represent the quantities of gas.

It may therefore be said, in a general way, that the distribution of pressure of fire-damp in the interior of a mass of coal is similar to that of temperature in a mass of the same form, and submitted to such thermic conditions as would be obtained by replacing the co-efficient of permeability by the co-efficient of conductibility, the pressures by the temperatures, the weight of gas discharged by the quantity of heat lost.

To apply this theory to some case, suppose a seam of coal, contained between two impermeable strata, and exposed by a face of indefinite length. The isobaric surfaces will be planes parallel to that of the face; then $s = s_o$, and the equation (1) becomes

$$\frac{dh}{dr} = \frac{k_o}{a},$$

whence

$$h - h_o = \frac{k_o}{a} r,$$

and also

$$h = \frac{k_o}{a} r,$$

if the atmosphere in contact with the face is free from gas, and if, consequently, $h_o = 0$.

This shows that, in this case, the pressure increases proportionally to the distance from the surface of the face. If $O\,M$ represent a line drawn from the face of the coal, perpendicular to the face, the pressure of the fire-damp corresponding to any point on this line will be represented by the ordinate of a line OA, whose angular co-efficient is $\frac{k_o}{a}$. From the point A, where the ordinate of the line is equal to the maximum pressure H of the fire-damp in the coal, the pressure remains constant, and is represented by a horizontal line.

Mr. Wood's experiments were not made at the face of a wide working place, but at that of a winning drift; it is, therefore, under these conditions that an endeavour must be made to compare theory with practice.

In order to avoid rendering the problem more complex, let it be assumed that the face of the drift, which is comprised between the roof and the thill, is a circular semi-cylinder, whose axis is normal to the

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stratification, and whose radius is half the width of the gallery. The actual face only differs from this hypothetical face by the suppression of two lateral prisms of coal of a relative small volume, and whose presence or absence can only have a slight influence upon the distribution of pressure at a certain distance from the surface.

Under these circumstances, the surface isobars are cylinders concentric with that of the face, and the orthogonal tubes are limited by planes normal to the stratification, and passing round the common axis of the cylinders.

In the equation (1) the following will then appear—

$$\frac{s}{s_o} = \frac{r}{r_o},$$

calling r the radius of the cylinder upon which the pressure h is exerted, and r_o that of the cylinder which bounds the surface. The equation (1) assumes the form

$$k_o r_o = ar \frac{dh}{dr},$$

whence

$$\frac{dr}{r} = \frac{a}{k_o r_o} dh.$$

On integrating, it becomes

$$\text{nat. log. } r = \frac{a}{k_o r_o} h + C.$$

Suppose that the pressure of the fire-damp in the atmosphere at the face is h, the constant C may be solved by making $h_o = 0$, for $r = r_o$, which gives

$$\text{nat. log. } \frac{r}{r_o} = \frac{a}{k_o r_o} (h - h_o).$$

In Mr. Wood's experiments it may be assumed that $h_o = 0$; the equation that these experiments should verify, if the hypothesis is exact, is then, by transforming the log. nep. into common logarithms,

$$h = \frac{k_o r_o}{a M} \text{ log. } \frac{r}{r_o}.$$

The verification can be made in a very simple way, by observing that if $h = y$ and $x = \text{log. } \frac{r}{r_o}$, the equation represents a line passing through the vertex.

Be it understood that it is only the experiments which are made simultaneously in the same mine, at points sufficiently near together, that can be compared, for the co-efficients k_o and a can vary greatly in different mines, as well as in different parts of the same mine.

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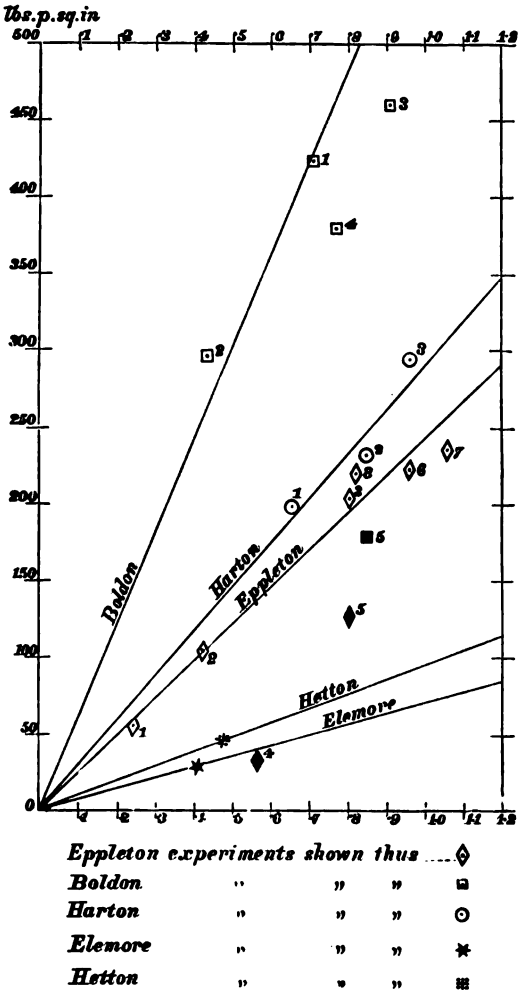
In proceeding with the verification of the hypothesis enunciated above, the fourth and fifth experiments at both Eppleton and Boldon, which were not made under circumstances to which the formula can apply, have been eliminated.



The experiments marked with shaded figures are not included in the calculations.

The results obtained in the experiments at Eppleton and Harton seem conformable to two straight lines passing through the vertex, and the differences do not appear to exceed those due to slight errors of observation.

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In the Boldon experiments the differences are much greater, but these experiments were the most difficult to make, owing to the great pressures to be measured; and the pressures obtained, especially the higher ones, do not appear to merit absolute confidence.

The following Table gives in another form the comparison of theory with the experiments:—

No. of the Exp.	Depth of the Hole. $r-r_o$. Ft.	In.	r. Ft.	In.	Log. $\frac{r}{r_o}$.	Pressure observed. h. Pounds per sq. in.	Calculated. h. Pounds per sq. in.
EPPLETON.							
1	3	6	8	0	·249	54·75	60·47
2	7	6	12	0	·425	104·50	103 22
*4	12	0	16	6	·564	31·	136·98
3	24	6	29	0	·809	204·	196·48
*5	25	6	30	0	·813	125·	197·45
8	25	0	29	6	·816	221·	198·18
6	37	0	41	6	·964	223·	234·12
7	47	0	51	6	1·058	235·	256·96
BOLDON.							
2	7	8½	12	2½	·433	298·	264·29
1	19	1	23	7	·719	425·	438·71
*4	23	5½	26	9½	·774	381·	472·42
*5	28	0	32	4	·856	176·	522·47
3	32	0	36	6	·909	461·	554·62
HARTON.							
1	16	2	20	8	·662	197·	192·78
2	27	6	32	0	·851	231·	247·82
3	37	3	41	9	·967	295·	281·61
ELEMORE.							
1	7	0	11	6	·407	28·	28·
HETTON.							
1	9	0	13	6	·477	45·	45·

It may be observed that in the same district of the same mine the increase of pressure in the seam does not follow the same law when the face is that of a narrow exploring drift as when it is that of a wide working place. In the latter case, the rate of the augmentation of pressure with the distance is necessarily less rapid, as the issue of the fire-damp is much more easy. This is the reason why the fourth and fifth experiments, at both Boldon and Eppleton, have given pressures much lower than those that would have been obtained if they had been made under the same conditions at the face of winning places.

* These experiments are not included in the calculations.

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Mr. Wood's experiments have verified the hypothesis as well as could have been hoped. It can, therefore, be considered as proved that fire-damp is contained in coal, like gas in a porous material, and that gassy seams are in reality gassy strata, comparable in every way with watery strata.

It follows that the gas can only be kept in the coal by a tight covering, capable of resisting the maximum pressure H of the fire-damp in the solid seam. This covering, in the bowels of the earth, can only be found in the superposed rocks. It follows then that these rocks are not porous, and that they are maintained by upper strata sufficiently heavy to balance pressures of 30 or 40 atmospheres, or perhaps even much greater pressures, for it cannot be said that the maximum pressure of the fire-damp in coal seams has yet been ascertained.

Many interesting suggestions may be made with regard to the history of the formation of coal and the coal measures.

In the first place it would appear that the coal must have been formed and covered before—and even long before—the formation of the gas, since the overlaying strata must at the time have had sufficient thickness and strength to have resisted its pressure; and if, as is believed, the formation of coal, in most cases, is due to the burial of vegetable matter, the transformation of this matter into coal had not taken place, or at least the change had not been completed, until new strata had accumulated to a considerable thickness above the coal seam.

Suppose that the burial of the vegetable matter took place at a very distant geological epoch, such as the carboniferous period, and during which it may be supposed that the earth was much warmer than it is now, and that the temperature due to the internal heat formed an important factor of the whole. At this epoch, when the coal was overlaid by 600 or 800 feet of rock, it might attain a temperature as high, or even higher, than 100° C. This temperature would be an energetic agent in the transformation, but this agent on the contrary would have been absent in the case of combustibles formed at more recent periods, and this, perhaps, will explain the very important differences which separate lignites from true coals. It would also account for lignites being usually free from fire-damp.

When a seam of coal is found exposed to the air at its outcrop, the fire-damp expands into the atmosphere, and the issue, at first rapid, diminishes more and more until it becomes almost inappreciable. If the seam was homogeneous, the fire-damp would finally disappear at the end of a period which, however, might be very long. But the seam may be divided into distinct and separate divisions by faults, by "nip-outs" filled

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with non-porous rocks, etc.; in this case, one of the divisions can be drained without the others losing their gas. Gas can thus be found in a seam which in closely adjacent places contained no gas whatever.

Even in the absence of these kinds of gas-tight walls, the distribution of the fire-damp in the same seam of coal can vary from one part to another, owing to variations of the co-efficient of permeability a. Every consideration points to the conclusion that this co-efficient is not a fixed constant, or more invariable, than any of the other properties of coal. This variation would cause the pressure to be comparatively highest in districts where the co-efficient a is of least value.

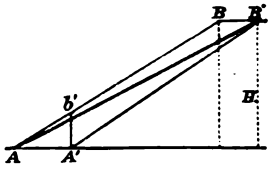
When the coal is in contact with a cavity produced by any fault, the gas will accumulate there until it attains a pressure equal to that it possessed when in the coal.

When the coal is found in contact with a bed of porous sandstone the fire-damp will accumulate in it if the gas is retained by an overlaying impermeable rock, and the sandstone will constitute another gaseous zone.

This theory offers, therefore, an explanation of the different circumstances and the curious variations attending the presence of fire-damp in a seam.

It will also explain the peculiarities, not less varied, of the issue of the gas in the workings.

Suppose a long-wall face opened in a seam of coal; at the end of a certain time the pressure of the gas in the solid coal, behind the face, is represented, at any given point, by the ordinate of a certain line AB,



which begins from zero at the face, and has the angular co-efficient $\frac{k_o}{a}$. The ordinate of this line is equal to the maximum pressure H, at a distance R from the face.

If the face remains intact, the superficial escape of gas k_o will go on gradually diminishing, and at the end of a time t the line AB will lower and take the position AB', and at the same time R will be increased.

If, on the contrary, by working a certain quantity of the coal, the face is advanced till it reaches the point A', a new section of coal is quickly

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exposed, in which the pressure of gas is $A'b'$; the escape of gas is made for some time in comparatively great quantities, and at the end of a time t, the distribution of the pressure is marked by the line $A'B'$. Such is the way in which the gas usually issues during the working of the coal. The escape is therefore, all things being equal, greater the more rapid the advance into the solid coal. It would therefore be better to have extensive workings than to rapidly advance in a small district; and for the same quantity of coal worked, when gas exists under the same conditions, the issue will be more abundant in a thin seam than in a thick seam.

In order that the dis-engagement may proceed with the regularity supposed, and in order that the issue of fire-damp may remain normal, it follows that the coal must possess a certain tenacity.

If, at any moment of the working, a superficial slice of coal, of the thickness r, is pressed at the inner side by a pressure h, and on the outer side by the pressure of the atmosphere h_o, the tenacity of the coal must be able to resist the pressure $h—h_o$. If r is small and $h—h_o$ great, which happens when the workings are driven rapidly, or when H is great and a little, $h—h_o$ will be great; if the tenacity of the coal is small, it may happen that the slice of coal of thickness r will be thrown off. The next slice, situated behind that which has been broken off, will be found pressed by a still greater difference of pressure, and it will be detached in its turn, and so on after the same manner. In a word, the coal will truly explode, and enormous volumes of gas will be suddenly set free, at the same time that corresponding quantities of coal will be reduced to powder.

Such is an explanation of the sudden outbursts of gas which have become so fatally developed in certain districts of Belgium. This explanation has been previously made by M. Arnould, and the theory deduced from the experiments of Mr. Lindsay Wood fully confirms it.

In mines subject to this description of accident it would be most desirable to drive galleries deeply into the solid in advance of the working face, and to make frequent measurements of the distribution of pressure, so as to check the advance of the workings when the rate of the increase of pressure exceeded a certain limit. This would be, perhaps, the most certain means of preventing these disastrous accidents.

Suppose two superposed gassy seams separated by an impermeable strata. If the upper seam is worked whilst the other two are not, the empty spaces resulting from the working of the coal do not leave the intervening strata sufficient support to enable it to resist the pressure of the gas in the lower seam. The thill of the working seam is therefore

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raised and fractured, and gives vent to more or less considerable quantities of gas. This may be an explanation of the sudden outbursts from the thill observed in a large number of the English collieries.

It can also be understood how these sudden outbursts can come out of the roof of the working seam when a gassy seam is situated above it.

Belgian miners (says M. Arnould in the paper already quoted) think that they can facilitate the working of the coal by diminishing the air at the working face, and thus augmenting the quantity of gas in the external air. This odd opinion accords with the above remarks, for if there is externally a pressure of gas equal to h_o, the pressure in the interior of the solid coal will be higher, beginning no longer from zero but from h_o. At any given depth from the face the pressure of the gas will be increased by h_o, and this pressure will be found to work wholly in favour of the miner. If the proportion of gas in the air is augmented by three per cent., the pressure h_o is equal to ·42 pounds per square inch or to 61·45 pounds per square foot. Such a pressure cannot be neglected in connection with the tenacity of the coal.

It is needless to prolong the study of the conclusions that can be derived from the exact knowledge of the existence of gas in coal; it is only necessary to have shown the interest of the problem.

The theory set forth is not new, and many others have more or less clearly expressed it. The investigations of M. Marsilly have already shown that there was indeed an actual independence between the coal and the gas contained in it. But Mr. Lindsay Wood's experiments confirm the theory in a strictly practical manner, and they permit the following fact to be distinctly enunciated:—

> That fire-damp is a gas contained in coal as water is in a porous rock. It is found compressed in it, under very variable pressures, which can attain to, and without doubt exceed, 460 pounds to the square inch.

Questions as to the mode of existence and mode of dis-engagement of fire-damp have thus acquired a solid foundation, upon which further experiments can build a more perfect theory. It would seem that the most useful thing to do now is to determine, by experiments, the value of the co-efficients designated by the letters k_o and a for a number of mines, that is, the volume of gas given off per unit of surface at the face at any time, and the co-efficient of permeability of the coal for the gas. These are the two data which constantly regulate, with the maximum pressure in the solid coal, the dis-engagement of gas.

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PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 10TH, 1883, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEO. BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the Proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

HONORARY MEMBER—

Professor P. PHILLIPS BEDSON, D. Sc. (Lond.,) College of Physical Science, Newcastle-on-Tyne.

ORDINARY MEMBERS—

Mr. HENRY JOHNSON, jun., Sandwell Park Colliery, West Bromwich, South Staffordshire.

Mr. MATTHEW LIDDELL, Prudhoe-on-Tyne.

ASSOCIATE MEMBERS—

Sir MATTHEW WHITE RIDLEY, Bart., M.P., Blagdon, Cramlington, Northumberland.

Mr. JOHN ALLAN, Eiderius Kreuz, Neugasse, Freiberg in Sachsen.

Mr. T. J. ARMSTRONG, Hawthorn Terrace, Newcastle-on-Tyne.

Mr. JOHN H. BURN, Coal Owner, 20, Broad Chare, Newcastle-on-Tyne.

Mr. JOHN BOWES, Streatlam Castle, Darlington.

Mr. CHARLES E. JEFFCOCK, B.A., Birley Collieries, Sheffield.

Mr. CHARLES LACY THOMPSON, Milton Hall, Carlisle.

Mr. F. D. JOHNSON, B.A., Aykleyheads, Durham.

Mr. A. E. BURDON, Hartford House, Cramlington, Northumberland.

Mr. WILLIAM THOMAS, M.E.. Mineral Office, Cockermouth Castle.

Mr. JOSEPH SNOWBALL, Seaton Burn House, Northumberland.

Mr. ROBERT ROWELL, Seghill Colliery Office, Newcastle-on-Tyne.

STUDENTS—

Mr. R. NOBLE HAIG, Lofthouse Mines, *via* Saltburn-by-the-Sea.

Mr. ROBERT J. W. OATES, Mining Surveyor, E.I.R. Collieries, Giridi, Bengal, India.

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The following were nominated for election at the next meeting:—

ASSOCIATE MEMBERS—

Mr. HENRY ARMSTRONG, M.E., St. Hilda Colliery, South Shields.

Mr. INGHAM H. WEBSTER, Rope Manufacturer, Morton House, Fence Houses.

Mr. PETER SINCLAIR HAGGIE, Gateshead-on-Tyne.

STUDENTS—

Mr. GEORGE HURST, Lauder Grange, Corbridge-on-Tyne.

Mr. DOUGLAS HAGGIE, Harton Colliery, South Shields.

Mr. C. H. STEAVENSON, Durham.

The following papers were taken as read:—

"On the Duration of the Coal of Great Britain and Ireland," by Mr. G. C. Greenwell.

"On the Daltonganj Coal-field," by Mr. J. H. Grant.

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THE DURATION OF THE COAL OF GREAT BRITAIN AND IRELAND.

By G. C. GREENWELL.

Much has been said and written on this subject. Large expenses have been incurred in its investigation; great pains have been taken and much thought has been bestowed in order that some foreknowledge might be obtained as to the period when the position of Great Britain, so far as it depends on its coal, may come to an end.

The writer will endeavour to show in the following pages that the line of argument which has hitherto appeared upon "the coal question" is inapplicable to this subject:—

1.—Because it has been assumed that there will, so long as coal lasts, be a continually increasing annual quantity of coal raised.

2.—Because it has been taken for granted that there could be locally placed upon the coal-fields such a population as would be able to produce the enormous quantities of coal which, on the above assumption, would require to be worked.

3.—That as, one after another, the various local fields have become exhausted, the still increasing quantity can be produced from those that remain.

4.—That the manufactures peculiar to a district, and dependent on the adjacent coal area for the supply of their requirements, will, on the exhaustion of the coal of that district, remove to others, and continue to flourish as they formerly did.

5.—That notwithstanding the constantly increasing ability of foreign countries to manufacture for themselves by means of that coal which, all over the world, is so largely in course of being developed, British manufactures requiring coal and British exports of coal will not only hold their own, but continue to advance in arithmetical or geometrical progression.

1.—The assumption that there will, so long as coal lasts, be a continually increasing annual quantity of it worked, does not appear to

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have any very substantial foundation. It is based upon the growth in the annual output of coal which has taken place hitherto. The following figures, taken from the best available sources, are given in illustration of the argument:—

	Production.		Home Consumption.		Export.	
Years.	Tons.	Increase per cent.	Tons.	Increase per cent.	Tons.	Increase per cent.
1860	83,923,273—Hunt	...	75,510.698	...	7,412,575—Meade	...
1870	112,875,725 } Inspectors'	34·498	101,173,076	32·234	11,702,649— Do.	57·876
1880	146,835,707 } Reports	30·086	128,133,156	26·529	18,702,551— Do.	59·814

It is not necessary to introduce the coal resources and annual production of Ireland into the question, the former being 155,680,000 tons and the latter being stationary at about 130,000 tons per annum; and in the calculations which follow there is no reference, unless specially, to that element.

From this Table it appears that in the ten years preceding and inclusive of 1870, there was an increase in the production of 34·498 per cent., while in the ten years preceding and inclusive of 1880, there was an increase of only 30·086 per cent.

In the same periods there was an increase in the export trade of 57·876 and 59·814 per cent. respectively; and, in the same periods, there was an increase in home consumption of 32·234 and 26·529 per cent. respectively. It will be seen from this, that in the production, there is a diminishing rate of increase in the latter as compared with the former decade, of 4·412 per cent., and in the home consumption of 5·705 per cent., while in the case of export there is an increasing rate of 1·938 per cent. The results of the period of 20 years are taken as the basis of the following Table, and are more complete and reliable than those at the command of others who have hitherto applied themselves to the question.

Estimated Production, Home Consumption and Export of Coals, per Annum, at the end of each Ten Years, from 1880 to 1940.

Years.	Production.	Home Consumption.	Left for Export.
1890	184,534,306	154,815,604	29,718,702
1900	213,769,990	178.222,175	35,547,815
1910	249.790,233	195,000,010	54,790,223
1920	280,859,142	202,232,560	78,626,582
1930	303,400,896	202,232,560	101,178,366
1940	314,365,804	202,232,560	112,133,244

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At the above rate the maximum of production will have been reached between 1930 and 1940; and of home consumption between 1910 and 1920. The quantity left for export does not give the same result as that produced during the 20 years preceding 1880, and it is extremely unlikely that the large increase in the export trade in coals should so continue.

At the above rate the total quantity of coal produced between January 1st, 1881, and January 1st, 1941, would be about 14,000 million tons.

In the year 1940, therefore, each colliery district would be required to produce about double its present output; and it is probable that should this quantity be reached, and it should prove to be the maximum, the trade will continue at about that level for many years before it begins to decline.

2.—It has been taken for granted that there could be locally placed upon the coal-fields such a population as would be able to produce the enormous quantities of coal which, on the above assumption, would require to be worked.

In the year 1940, when by the above computation the annual production will have reached its maximum of 314 million tons, it will, according to the late Professor Jevons, have increased to 1,310 million tons, and in only 20 years afterwards to 2,607 million tons, provided that the rate of growth of 3½ per cent. per annum be maintained. In a work on "Coal, its History and Uses," by Professors Green, Miall, Thorpe, Rücker, and Marshall, it is calculated that, by arithmetical rate of increase, the production in 2150 will be 945 millions; and, by geometrical rate, that in 2000 it will be 6,000 million tons per annum; but they add that, taken literally, both assumptions are obviously untenable, as they imply that at one or other of the above dates an output of 945 million or 6,000 million tons of coal per annum will come to a sudden stop; "so that in the year immediately following and for ever after, not one ton of coal ever will be raised more in the United Kingdom; or, at all events, not a ton be left anywhere to be worked at a less depth than 4,000 feet."

For the purpose of the present argument the writer will take the estimates of coal remaining unworked, contained in the Report of the Royal Coal Commission, 1871 (Ireland excluded). Coal in known coal-fields in depths not exceeding 4,000 feet 90,051,605,398. Of this quantity 32,456,208,913 tons are contained in the South Wales coal-field, being approximately one-third of the whole. The great resources of this coal-field will ensure its existence long after most of the others have been exhausted, but take the favourable assumption that the coal-fields individually are exhausted in an equal degree, proportionally to the

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quantity of coal contained in them. If then, in 1941, the total output should reach 1,310 million tons, the output of South Wales will be 436 millions of tons. As it will be seen on reference to the coal returns of South Wales that it requires (1881) 53,452 persons to produce 16,008,525 tons of coal, equal to 300 tons per head, the number of persons who will be required in 1941 will be 1,453,333. Twenty years afterwards the output would be 869 millions of tons, and the number of persons would be all but doubled.

To produce the full output of 2,607 millions of tons would require, at the general rate of work per head in the British coal-fields (327 tons per head) 7,972,477 persons, or a colliery working population alone, all located in the colliery districts, far in excess of the present population of Great Britain:—

England and Wales	25,968,286
Scotland	3,735,573
	29,703,859
Females, say	15,703,859
Males of all ages	14,000,000

3.—That as, one after another, the various coal-fields have become exhausted, the still increasing quantity can be produced from those that remain.

Not including 1,500 million tons of coal added to Mr. George Elliot's (now Sir George Elliot, Bart.) estimate of the coal remaining in the Durham coal-field in the beginning of 1871, lying beyond a distance of 3½ miles seaward (that for Northumberland and Cumberland having been confined to 2 miles) the quantity remaining to be worked at that date was:—

	Tons.
In Northumberland, Cumberland, and Durham	8,941,844,028
From which must be deducted the quantity worked from January 1st, 1871, to January 1st, 1882, namely	359,255,220
Remaining January 1st, 1882	8,582,588,808
And the production of these Counties in 1881 was	37,370,529

Without calculating on any increase of production at all, these coal-fields would be exhausted in 230 years.

	Tons.
In the case of South Wales, the quantity of coal remaining on January 1st, 1871, was	32,456,209,913
Deduct the quantity worked from January 1st, 1871, to January 1st, 1882	131,297,444
Leaving	32,324,912,469

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Which, at the 1881 rate of production, would not be exhausted until the expiration of 2,000 years.

Whatever expansion in the demand for coal takes place will in all probability affect in a somewhat equal manner the two coal-fields, by reason of their similar position, and it is a fact not to be overlooked that the royalties, or coal properties, are now very largely under lease in both fields. But, supposing the period of 230 years or any shorter period has arrived when no more coal is to be had in Northumberland and Durham, can it be seriously believed that a working population of 100,000 persons, and perhaps vastly more, would be transplanted to South Wales in order that there might be no failure in the aggregate production of the two districts?

4.—That the manufactures peculiar to a district, and dependent on the adjacent coal area for the supply of their requirements, will, on the exhaustion of the coal of that district, remove to others and continue to flourish as they formerly did.

The Cleveland ironstone is dependent on the coke produced in the Durham coal-field: if the coal from which it is manufactured were exhausted, either the Cleveland ironstone (in order to be utilized) would require to be taken to other coal-fields, or the coal from other coal-fields would require to be transported to Cleveland. Were either of these the effect of the above exhaustion, iron would cease to be produced from Cleveland ironstone at anything like its present cost: the inevitable result would (having due regard to the effect produced by Cleveland on the trade) be a considerable rise in the price of iron generally, a consequent diminution of its production, and a corresponding diminution in the quantity of coal raised. The same would apply to the Cumberland iron-works as well as to Scotland, in the event of the exhaustion of the coal of West Scotland suitable for iron-making. This rise in the price of iron, taken in conjunction with the rapidly increasing production of iron in other countries, would probably put a stop to the export of iron, and perhaps later, of machinery and materials manufactured from it.

Chemical works, on account of the nature of their trade, must be situated conveniently for import and export, consequently at or near some port of shipment, where there is ample accommodation. They, probably as much as any other branch of British trade, feel the effect of foreign competition. If the cheap fuel they obtain on the banks of the Tyne or the Mersey, or at Glasgow, were no longer obtainable, chemical works, on a large scale, would cease altogether.

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5.—That, notwithstanding the constantly increasing ability of foreign countries to manufacture for themselves by means of coal which, all over the world, is so largely in course of development, British manufactures requiring coal and British exports of coal will not only hold their own, but continue to advance in arithmetical or geometrical progression.

There is no doubt a great deal in a name, and with such an introduction as British manufacture possesses, it will for a long period maintain its markets and no doubt increase its trade in those to which it has even equal access with other countries. It is very much to be feared, however, that the pressure of competition with them, and the consequent increased competition at home, will not in the long run maintain the character of the axe, "if the steel be left out." With the ability to supply the world, how does it even now happen that English manufacturers are undersold at home by the importation of foreign rails, girders, tools, and other things, all of which are largely produced by means of coal, the trade in which is expected to advance as rapidly as it did previously to the importation of such things from abroad?

The writer hopes he has, to some extent at least, shown the fallacy of the early failure of the British coal-fields, due to the estimated enormous additional quantities of coal that they may annually be called upon to supply; and he will now proceed to the more practical question as to how long at the present rate of extraction the great known coal-fields of Great Britain will last. The writer takes as a starting point the estimate of the Royal Coal Commission, of 1871, but as he cannot accept the estimate of extension of the Durham under-sea coal beyond an average of 3½ miles from the Durham Coast, he rejects 1,500 millions of tons from the gross estimate of 90,051,605,398, and as this quantity includes in some instances coal lying between 3,000 and 6,000 feet deep, a further deduction on that account is made. These deductions reduce the quantity left on January 1st, 1871, to 88,304,332,285, distributed among such Inspection districts, as by railway facilities, may be considered within the limits of six great coal-fields, as follows:—

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ROYAL COAL COMMISSION.

ESTIMATED QUANTITY OF COAL IN SEAMS OF 12 INCHES THICK AND UPWARDS, AND LYING ABOVE THE DEPTH OF 4,000 FEET, REMAINING TO BE WORKED AT JANUARY 1ST, 1871.

GREAT BRITAIN.

	Inspection Districts.	Authority.	Tons.	Tons.
Nos. 1 & 2	Northumberland ...	Mr. T. E. Forster	2,744,896,839	
	Do. sea coal, 2 miles	Do.	403,200,000	
	Cumberland	Do.	303,827,792	
	Do. sea coal, 2 miles	Do.	101,376,000	
	Limestone coal	Do.	665,180,007	
	Durham	Mr. G. Elliot ...	3,988,854,385	
	Do. sea coal, 3½ miles	Do.	734,509,005	
				8,941,844,028
Nos. 3 & 4	Lancashire...	Mr. Dickinson ...	5,313,443,000	
	Anglesey	Do.	5,000,000	
	Denbighshire	Do.	1,287,000,000	
	Flintshire	Do.	718,000,000	
				7,323,443,000
Nos. 5 & 6	Midland	Mr. Woodhouse...	18,172,071,430	
	Moira district	Do.	454,161,946	
	Coleorton do.	Do.	382,637,788	
	Warwickshire	Do.	458,652,714	
	Outliers, Midland ...	Do.	70,964,011	
				19,538,487,889
Nos. 7 & 8	North Staffordshire ...	Mr. Elliot	3,825,488,105	
	Cheshire	Mr. Dickinson ...	200,000,000	
	South Stafford, etc. ...	Mr. Hartley ...	1,906,119,768	
				5,931,607,873
Nos. 9 & 10	Somerset & Gloucester	Mr. Prestwick ...	4,218,970,762	
	Forest of Dean	Mr. Dickinson ...	265,000,000	
	South Wales	Mr. H. Vivian ...	19,278,272,740	
	Do.	Mr. Clarke ...	12,963,240,063	
				36,725,483,565
Nos. 11 & 12	Scotland	Mr. Geddes ...	...	9,843,465,930
			Total	88,304,332,285

N.B.—The North Staffordshire and Cheshire Inspection District includes Shropshire, but the Shropshire coal is included in the South Staffordshire estimates.

IRELAND.

Inspection District.	Authority.	Tons.
No. 3.	Mr. Edward Hull.	155,680,000.

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The estimated quantity of coal, as above, remaining unworked at January 1st, 1871, was:—

	Tons.
Great Britain	88,304,332,285
Deduct the quantity worked from January 1st, 1871, to January 1st, 1882	1,464,020,265
Quantity remaining at January 1st, 1882 ...	86,840,312,020
Which, at the rate of production in the year 1881, will be exhausted in	563 years.
The total quantity estimated to exist in Ireland, if divided by the quantity produced in Great Britain in 1881, would give a supply for	1 year.

The writer will, in the next place, give abstracts from the Reports of Her Majesty's Inspectors of Mines, showing in each year, commencing with that of the Report of the Royal Commission, the number of persons employed under-ground and above-ground, and the number of tons raised in each Inspection district.

The following is an account of the number of persons employed in the coal mines of each Inspection district of Great Britain and Ireland in each year, from the 1st January, 1870, to the 1st January, 1882, together with the tons of coal raised:—

1.—NORTHUMBERLAND, ETC.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Aboveground.	Underground.	Total.		
Computed 1871	...	...	36,000	12,530,000	348·05
Computed 1872	...	...	39,000	13,010,000	333·59
1873	10,108	37,100	47,208	13,471,104	285·35
1874	9,669	39,460	49,129	13,692,272	278·70
1875	10,244	39,826	50,070	14,042,822	280·46
1876	10,118	38,636	48,754	14,135,104	289·92
1877	9,575	38,444	48,019	13,316,156	277·31
1878	9,094	36,300	45,394	12,913,851	284·48
1879	9,174	36,688	45,862	13,167,369	287·10
1880	9,490	38,030	47,520	15,606,849	328·42
1881	9,627	37,769	47,396	15,830,720	334·01
			504,352	151,716,247	Av. 300·81

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2.—DURHAM.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	43,000	17,946,000	417·35
Computed 1872	...	...	45,300	17,395,000	383·99
1873	42,278	11,079	53,357	17,438,017	326·81
1874	44.972	10,724	55.696	17,912,543	321·61
1875	46,868	11,727	58.595	19,459.248	332·10
1876	46,365	12,015	58,380	19,520.923	334·37
1877	45,016	11,429	56,445	19.556,418	346·46
1878	42,795	10.111	52.906	18,620.912	351·96
1879	39,748	9,827	49,575	17,155.383	346·04
1880	42.829	10,411	53.240	20.994.720	394 34
1881	43,665	11,160	54.825	21,539,809	392·88
			581,319	207,538,973	Av. 357·01

3.—NORTH AND EAST LANCASHIRE (EXCLUSIVE OF IRELAND).

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	26.110	7,575,800	290·15
Computed 1872	...	...	28,657	9,363,236	326·73
1873	26,429	5,453	31,882	8,063,855	252·92
1874	27,166	5.662	32,828	8,063,974	245·64
1875	27,305	5,701	33,006	8,881,137	269·07
1876	25.048	5,334	30,382	8,364,179	275·30
1877	24,154	5,190	29,344	8,741.387	297·89
1878	24,726	5,063	29,789	8,633.839	289·83
1879	25,495	5.262	30,757	8,993.697	292·41
1880	25,552	5,445	30,997	9,519,858	307·12
1881	26,274	5,399	31,673	9,326,722	294·46
			335,425	95,527,684	Av. 284·79

3*a*.—IRELAND.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Hunt's Statistics 1871	...	...	...	165,750	...
Hunt's Statistics 1872	...	...	...	103,463	...
1873	1,209	741	1,950	135,731	69·60
1874	1,120	531	1,651	139,213	84·32
1875	1,069	475	1,544	128,201	83·09
1876	946	419	1,365	125,195	91·71
1877	883	365	1,248	140,181	112·32
1878	841	381	1,222	122,051	99·87
1879	819	296	1,115	129,003	115·69
1880	777	294	1,071	133,702	124·83
1881	771	299	1,070	127,585	119·23
			12,236	1,450,075	Av. 96·50

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The estimated quantity of coal, as above, r
January 1st, 1871, was:—

Great Britain ... ...
Deduct the quantity worked from January 1st, 1871, t
January 1st, 1882 ... ...

Quantity remaining at January 1st, 1882 ...

Which, at the rate of production in the year 1881, will
be exhausted in ... ...
The total quantity estimated to exist in Ireland, if
divided by the quantity produced in Great Britain
in 1881, would give a supply for ... ...

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1.—NORTHUMBERLAND, ETC.

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	Aboveground.	Underground.	Total.	
Computed { 1871	...	...	36,000	12,530,000
{ 1872	...	...	39,000	13,010,000
1873	10,108	37,100	47,208	13,471,104
1874	9,669	39,460	49,129	13,692,272
1875	10,244	39,826	50,070	14,042,822
1876	10,118	38,636	48,754	14,135,104
1877	9,575	44	48,019	13,316,156
1878	9,094	0	45,394	12,913,851
1879	9,174		45,862	13,167,369
1880	9,4		47,520	15,606,849
1881	9,6		47,396	15,830,720
			504,352	151,716,247

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4.—West Lancashire and North Wales.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	32,218	8,775,000	272·36
Computed 1872	...	...	34,000	9,000,000	264·70
1873	33,018	9,282	42,300	10,288,583	243·22
1874	33,796	9,862	43,658	9,875,762	226·20
1875	35,014	10,122	45,136	11,398,032	252·52
1876	32,661	9,513	42,174	11,509,339	272·90
1877	31,128	9,214	40,342	11,426,745	283·24
1878	30,817	8,207	39,024	11,651,797	298·58
1879	31,398	8,060	39,458	11,783,724	298·63
1880	31,636	7,818	39,454	12,029,751	304·90
1881	31,631	7,999	39,630	11,843,685	298·85
			437,394	119,582,418	Av. 273·39

5.—Yorkshire.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	38,600	12,801,260	331·65
Computed 1872	...	...	51,056	14,576,000	285·49
1873	45,828	11,695	57,523	15,311,778	266·18
1874	49,683	12,816	62,499	14,827,313	237·24
1875	49,006	13,184	62,190	15,855,990	254·96
1876	48,367	12,650	61,017	15,129,506	247·95
1877	47,808	12,786	60,594	15,805,235	260·83
1878	47,985	11,792	59,777	15,582,283	260·67
1879	48,327	11,760	60,087	16,241,443	270·29
1880	48,654	11,820	60,474	17,468,536	288·86
1881	48,674	11,857	60,531	18,287,141	302·11
			634,348	171,886,485	Av. 270·96

6.—Midland, Derby, Notts, etc.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	31,051	9,252,900	297·99
Computed 1872	...	...	39,285	10,657,100	271·27
1873	36,544	10,430	46,974	11,533,407	245·52
1874	40,673	11,706	52,379	12,232,296	233·53
1875	40,789	11,688	52,477	12,430,600	236·87
1876	40,260	12,088	52,348	12,331,546	235·56
1877	38,788	11,497	50,285	12,903,886	256·61
1878	38,170	11,184	49,354	13,440,184	272·32
1879	39,222	11,701	50,923	14,036,242	275·63
1880	37,960	11,370	49,330	14,500,995	293·95
1881	38,365	11,614	49,979	15,545,667	311·04
			524,385	138,864,823	Av. 264·81

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7.—North Staffordshire, Cheshire, etc.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	21,200	6,500,000	306·60
Computed 1872	...	...	27,753	6,327,188	227·97
1873	23,177	7,444	30,621	6,257,468	204·35
1874	23,494	8,250	31,744	6,289,929	198·46
1875	22,480	7,576	30,056	6,116,194	203·49
1876	20,581	7,198	27,779	5,559,106	200·11
1877	20,010	6,121	26,131	5,742,020	219·74
1878	18,694	5,907	24,601	5,584,400	226·99
1879	17,918	5,243	23,161	5,562,645	240·17
1880	17,814	5,038	22,852	5,660,800	248·15
1881	18,856	5,643	24,499	6,473,900	264·25
			290,397	66,073,650	Av. 227·52

8.—South Staffordshire and Worcester.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	31,000	10,500,000	338·70
Computed 1872	...	...	31,500	10,550,000	334·92
1873	27,497	9,332	36,829	11,100,000	301·39
1874	27,304	9,551	36,855	8,500,000	230·63
1875	26,457	9,211	35,668	10,300,000	288·77
1876	24,476	8,322	32,798	10,000,000	304·89
1877	21,483	7,277	28,760	9,500,000	330·31
1878	18,681	6,422	25,103	8,976,000	357·56
1879	17,641	5,914	23,555	9,329,197	396·06
1880	17,563	5,930	23,493	9,660,000	411·18
1881	17,887	5,919	23,806	10,058,670	422·52
			329,367	108,473,867	Av. 329·34

9.—Monmouthshire, Somerset, etc.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	26,881	7,000,000	260·40
Computed 1872	...	...	32,471	7,000,000	215·57
1873	28,352	7,000	35,352	6,749,264	190·91
1874	28,161	6,691	34,852	6,815,787	195·56
1875	28,225	5,911	34,136	6,113,413	179·08
1876	27,566	5,678	33,244	7,121,209	214·21
1877	26,820	5,086	31,906	7,056,136	221·15
1878	26,010	4,864	30,874	7,152,258	231·65
1879	25,483	4,577	30,060	7,439,627	247·49
1880	25,101	4,710	29,811	7,835,483	262·83
1881	26,206	4,838	31,044	8,318,821	267·96
			350,631	78,601,998	Av. 224·17

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10.—South Wales.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	37,960	9,120,000	240·25
Computed 1872	...	...	38,427	10,131,720	263·66
1873	37,121	9,443	46.564	11,473,152	246·39
1874	41,684	9,829	51.513	11,452.358	222·31
1875	42.784	8,464	51,248	9.983,341	194·80
1876	38,802	7,517	46,319	11,663,447	251·80
1877	37.637	7,175	44,812	11,671,730	260·45
1878	37,080	6,854	43,934	12,097,206	275·34
1879	40,344	7.620	47,964	12,412.136	258·78
1880	42,242	8,174	50,416	15.283,829	303·11
1881	44,939	8,513	53,452	16,008,525	299·48
			512,609	131,297,444	Av. 256·13

11.—East Scotland.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	27,300	8,883,926	325·41
Computed 1872	...	...	30,000	9.046,814	301·56
1873	29,880	5,854	35,734	10,142,039	283·82
1874	31,294	6,254	37,548	10,182,326	271·18
1875	29,321	6,080	35,401	11,419,619	322·57
1876	28,765	6,139	34,904	11,667,648	334·27
1877	27,422	5,798	33,220	11.452,373	344·74
1878	28,616	5,802	34,418	11,667,559	338·99
1879	29,289	5,831	35,120	11,300,567	321·77
1880	29,559	5,980	35,539	12,019,443	338·20
1881	30,402	6,215	36,617	14,148,880	386·40
			375,801	121,931,194	Av. 324·45

12.—West Scotland.

Years.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	19,561	6,554,365	335·07
Computed 1872	...	...	20,639	6,336,795	307·03
1873	19,365	3,426	22,791	6,715,733	294·66
1874	19,020	3,600	22,620	6,606,335	292·05
1875	17,507	3,489	20,996	7,177,888	341·86
1876	16,342	3,294	19,636	6,997,964	356·38
1877	15,516	3,332	18,848	6,867,701	364·37
1878	14,534	2,913	17,447	6,169,723	353·62
1879	14.899	2,812	17,711	6,169,360	348·33
1880	14,703	2,888	17,591	6,255 443	355·60
1881	14,399	2,824	17,223	6,674,175	387·51
			215,063	72,525,482	Av. 337·22

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The following is an account of the number of persons employed in the coal mines of Great Britain and Ireland in each year, from the 1st January, 1870, to the 1st January, 1882, together with the tons of coal raised: —

Year.	Number of Persons Employed.			Tons Raised.	Tons Raised per Person Employed.
	Underground.	Aboveground.	Total.		
Computed 1871	...	...	370,881	117,439,251	316·65
Computed 1872	...	...	418,088	123,393,853	295·13
1873	386,589	100,546	487,135	128,544,400	263·87
1874	406,707	104,614	511,321	126,450,895	247·30
1875	405,582	103,397	508,979	133,178,284	261·65
1876	387,869	99,866	487,735	133,999,971	274·73
1877	374,226	94,480	468,706	134,039,787	285·97
1878	364,418	88,203	452,621	132,490,012	292·71
1879	366,452	87,781	454,233	133,591,390	294·10
1880	371,643	89,074	460,717	146,835,707	318·71
1881	379,067	91,608	470,675	154,056,715	327·31
			5,091,091	1,464,020,265	Av. 287·56

In order as nearly as possible to compare the six centres of coal with the present annual production thereof, the following Table has been constructed out of the foregoing abstracts:—

Coal-fields.	Coal in known coal-fields, Jan. 1, 1882.	Production in 1881 of Inspection Districts.		Years of Life.
	Tons.		Tons.	
Northumberland, Durham, and Cumberland	8,582,588,808	1 & 2	15,830,720 21,539,809	230
Lancashire, Anglesey, Denbighshire, and Flintshire	7,108,332,898	3 & 4	9,326,722 11,843,685	336
Midland, Leicestershire, Warwickshire, etc.	19,227,736,581	5 & 6	18,287,141 15,545,667	562
North and South Staffordshire and Cheshire	5,757,060,356	7 & 8	6,473,900 10,058,670	349
Somerset, Gloucester, and South Wales	36,515,584,123	9 & 10	8,318,821 16,008,525	1501
East and West Scotland ...	9,649,009,254	11 & 12	14,148,880 6,674,175	463
Totals	86,840,312,020		154,056,715	573

According to the Royal Coal Commissioners, there will be in England a probable amount of coal (in addition to the above) under Permian and other overlying formations at depths of less than 4,000 feet, 40 per cent. deducted for loss and other contingencies, equal to 56,246 million tons, and this quantity would be equal to a supply for 365 years at the present rate of production. This quantity of coal is, however, all confined to the

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Midland Counties of England, and $\frac{2}{3}\frac{3}{3}$ths of it are in Yorkshire, at present nearly the richest coal-field in Great Britain. The above estimates include large quantities of coal contained in seams of from 12 inches to 2 feet in thickness, which may possibly be worked for local consumption.

The object of the writer has been to endeavour to disprove the estimates and calculations by which it has been shown by men of great logical skill that the British coal-fields were, in the course of a few generations, to be "used up." Statistics, it is said, may be used to produce any, no matter what, result. The only deduction now endeavoured to be drawn from them, is that after no long period the maximum of the production of British coal will have been attained. The basis, however, seems too limited, but no better is to be had; also, the conclusions herein arrived at by calculation are far too high. On reference to the Tables it will be found that the number of persons employed underground has decreased from 386,589 in 1873 to 379,067 in 1881; that the production has increased, notwithstanding, from 128,544,400 in 1873 to 154,056,715 tons in 1881, or, in other words, that in 1873, when there was full employment, the production per person employed underground was 332½ tons, whereas in 1881, when want of employment was the general complaint, the production was 406½ tons. But this must have a limit.

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THE DALTONGANJ COAL-FIELD.

By J. H. GRANT.

Daltonganj is a civil station on the banks of the Koel, about 85 degrees east longitude and 24 degrees north latitude, and about 80 miles south-west of Gya, which latter is a town of some importance, being in communication, by a branch line, with the Great Indian Railway running from Calcutta to Delhi, and about 115 miles due south of the Ganges.

Immediately to the north of this station is the Daltonganj coal-field, a description of which, giving all the information connected with the geology of the country which was known up to 1869, is given by Mr. Theo. W. H. Hughes, F.G.S., in the "Memoirs of the Geological Survey of India," 1872, p. 325. This coal-field is nearly 150 miles due west of the Kurhurballee Coal-field, so ably described by Dr. W. Saise in Vol. XXX. of the Transactions.

In the middle of the year 1882 the writer was ordered to inspect this field, and, after arriving at Gya by rail, had to make the rest of his way in a polkee, with a "dooly" (litter) for the luggage, and a nondescript conveyance for his servant. This part of the journey lay through a noted tiger jungle and was very irksome to traverse, there being only one station, Shergatti, which lies on the main road between Calcutta and Benares. This part of the journey took three days, travelling being rendered somewhat difficult on account of the rains which had set in.

In speaking of this coal-field Mr. Hughes says, p. 329 of the Memoirs before referred to:—

"Hitherto it has been the custom to call this field the Palámaun (or Palamow) and not the Daltonganj coal-field. There are, however, many coal-bearing areas within the district of Palámaun, and the name, consequently, of the Palámaun field, as applied to any one of them, is not sufficiently distinctive.

"The designation would be admissible did any Coal-measures occur near the town of Palámaun; but that town happens to be far distant from any locality in which Coal-measures exist.

"To indicate, therefore, more precisely the geographical position of the field I am now describing, I have thought it better to discard the title

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of Palámaun, and, in seeking a fresh name, to adopt that of 'Daltonganj,' from the civil station of Daltonganj, which lies just beyond the southern borders of the field."

The accompanying Map, Plate XIII., will assist the reader in following the description of the coal-field.

Palámaun is a sub-division of the district of Lohardagga, and a part of the Chotá Nágpúr district, and is situated about 80 miles nearly due south of Gya. The suddir, or chief station, is Daltonganj, a pretty little place on the banks of the Koel river.

The general appearance of Palámaun is that of a hilly district. A succession of hills and hill ranges meet the traveller on all sides. Cultivation therefore is sparse, and the people depend more upon what are known as jungle products than on ordinary crops, such as lac, tasar silk, mowah, etc. The country is thinly inhabited, and the villages, compared to those of lower Bengal, notably Burdwan, Beerbhoom, and Hooghly districts, small, mean, and poverty-stricken. The population is chiefly Hindoo and embraces the usual castes, from the brahmin (priest) to the luchtur (sweeper).

The Daltonganj field comprises an area of about 200 square miles, but of this not more than 25 can be taken as belonging to the Carboniferous formation.

The general appearance of the Daltonganj field is that of an undulating plain, intersected by broad and shallow streams, dry, or nearly so, during the cold and hot seasons, but rapid and dangerous torrents during the rains.

The principal rivers are the Koel, a tributary of the Son which flows into the Ganges near Dinapoor, the Amanat, and the Jinjoi, tributaries of the Koel.

Adopting the method of the Geological Survey of India, the following is the usual sequence of the Carboniferous rocks in this country:—

III.—Panchét, from a hill of that name.
- 1.—Upper.
- 2.—Lower.

II.—Damúdá, from the river of that name.
- 1.—Ránigánj series.
- 2.—Carbonaceous shales.
- 3.—Barákar or Lower Damuda.

I.—Talchír (at base).—This may be looked upon as the bottom bed or "farewell" rock.

In the Daltonganj field the Talchír series, and the Lower Damúdás or Barákars, are the only representatives of the coal-bearing rocks.

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To illustrate Mr. J.H. Grant's paper

Proceedings N° E1 of M.& M.E. 1882-83.

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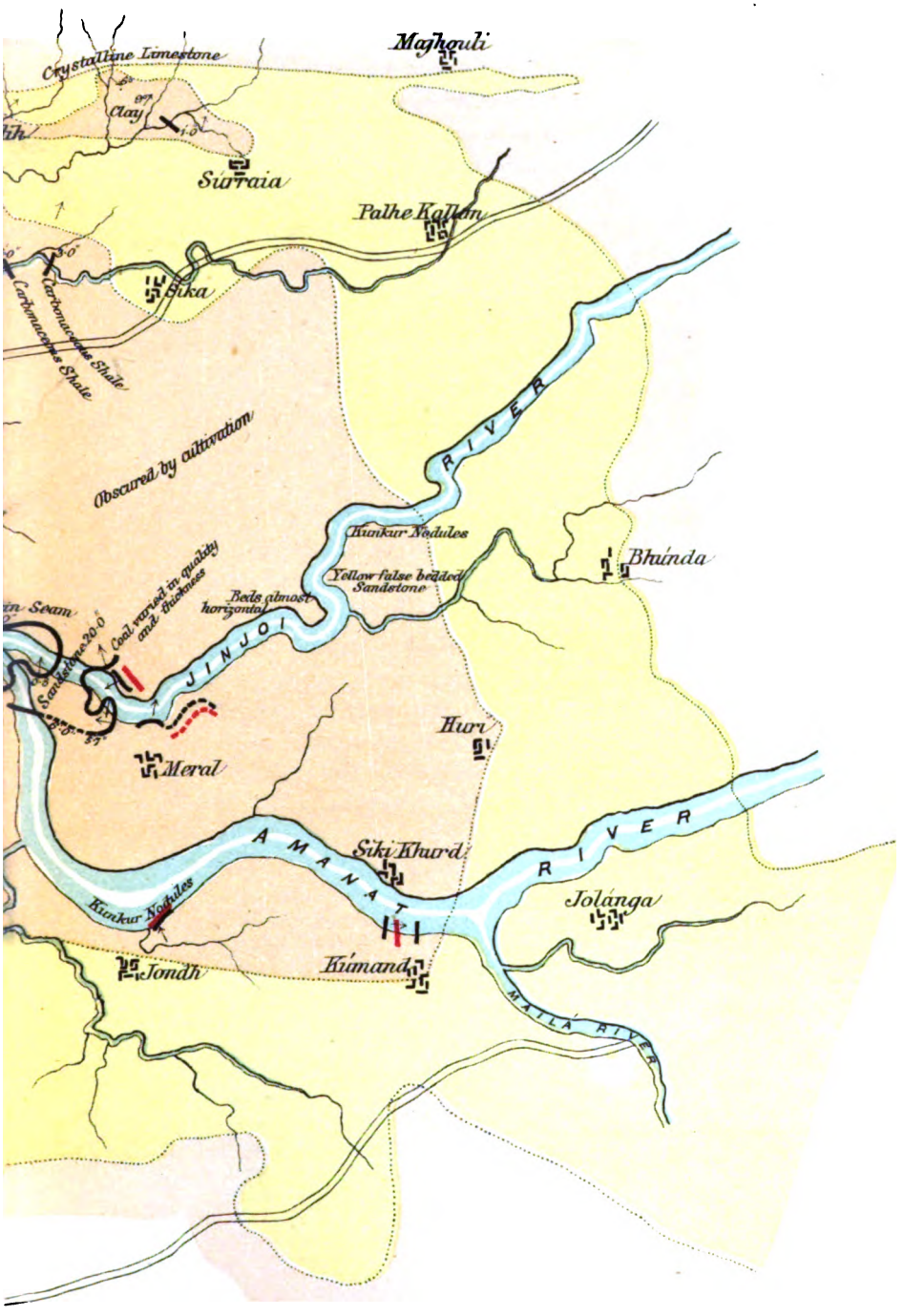

And.r Reid, Newcastle

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Of the Talchír little need be said: they are well developed, displaying the usual lithological peculiarities which characterize the series—boulder bed, sandstones, and shales. In the Daltonganj area the sandstones predominate, the dip is slight, and but little faulting is apparent. The total thickness may be about 600 feet.

To the palæontologist this series is utterly devoid of interest.

The Damúdás series is represented by the Barákar group only. Although true Barákars, any one acquainted with the typical rocks in and around Barákar only would have some difficulty in recognising these sandstones as being part and parcel of the Carboniferous series, instead of the dense fine-grained grey sandstones, which are so highly valued as building material, and the coarse micaceous sandstones, with the accompanying conglomerate beds so well known at Barákar. There are found in the Daltonganj field fine smooth yellow sandstones with but a faint trace of mica, very friable, and of no economic value. Several seams, which it was the writer's good fortune to discover, are marked on the map in red. Taking the Barákar group (coloured sepia) and beginning at the east, the lowest beds seen are exposed in the bed of the Amánat river, north of the village of Kúmand. The beds are soft yellowish sandstones with several thin and very impure seams of coal.

At Kúmand there are two seams of impure coal, one 1 foot 6 inches, and the other 2 feet thick, they are of no economic value. Proceeding down the Amánat a series of sandstones and shales are seen, with a low dip, and false bedded. No coal appears for some 5 miles; but near the village of Meral on the Jinjoi river, four seams present themselves, and at this spot the writer had a couple of bore-holes put down, one just north-west of the village, and the other on the opposite bank of the Jinjoi. The sections these holes gave are as follows, and prove the existence of a valuable and rich field:—

BORE-HOLE No. 1.

	Ft.
Alluvium	6
Yellow sandstones	28
Shale	2
Coal	8
Shale	1
Sandstone	6
Shale	1
Coal	5
Sandstone	19
Coal	4
Sandstone	7
Coal	8
Shale	2
	97

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BORE-HOLE No. 2.

	Ft.
Alluvium	7
Sandstone	43
Coal	6
Sandstone	11
Coal	6
Sandstone	17
Coal	4
Sandstone	5
Coal	10
Shale	1
Talchir sandstone	—
	110

Mr. Hughes is perhaps inclined to somewhat undervalue the importance of this coal-field; of course, if compared to the Ránigánj or Kurhurballee fields, it must rank as a small one, but looking to its position, situated so far from any other source of supply, the writer considers it as a most valuable addition to the mineral wealth of this singularly favoured land.

As regards the quality of the mineral, it will favourably compare with many of the Ránigánj coals. The following are the results obtained from samples which had been exposed to the air during one whole tropical rainy season:—

I.

	Per Cent.
Carbon	65
Volatile matter	21
Ash	14
	100

II.

Carbon	67
Volatile matter	19
Ash	14
	100

III.

Carbon	66
Volatile matter	20
Ash	14
	100

IV.

Carbon	69
Volatile matter	23
Ash	8
	100

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Mr. Hughes in his report to the Government says:—"10 to 13 per cent. of ash is in excess of the better kinds of Damúdá coal (Ránigánj), but for ordinary purposes this amount of inorganic matter is no serious drawback. The coal of this field is capable of performing the work which Ránigánj coal has hitherto accomplished."

The total quantity of coal actually available is put down by Mr. Hughes at 11,600,000 tons. The writer is inclined to place the total available quantity at nearly double those figures, for Mr. Hughes has apparently not taken into consideration the available fuel at Meral (see Plate XIII.), but has based his calculations on the coal at Rájhéra in the extreme north of the field.

A scheme is now before the Secretary of State for India which has received the sanction of the Local Government for the utilization of this field by the construction of a railway to a place called Baroon at the head of the Son canal system, which would bring the fuel into favourable competition with the Ràniganj or Kurhurballee coals as regards the important trading centres of Buxar, Dinapoor, Benares, and Allahabad, to say nothing of the local demands which a railway always creates. The following is copied from the "Coal Resources and Production of India:"—

COALS RAISED BETWEEN THE YEARS 1859 AND 1862.

	Maunds.*
1859	28,648
1860	30,900
1861	33,343
1862	43,772

The quarries have not been worked since 1862.

In addition to the coal the Talchir group furnishes a fine-grained sandstone to the builder, and iron ores are abundant.

Kankar, or what is known as ghooting limestone, a pebbly carbonate of lime, is to be found in large quantities in almost all parts of the field; but although iron and sufficiently good limestone as a flux are abundant, the writer does not think that iron smelting could be carried on in the district with the coal; for a few years charcoal furnaces might be run, but Indian jungle requires from five to seven years to recoup itself, and, therefore, fuel would soon become both scarce and expensive; but as a coal-field, considering the position, it is one of the most important in Bengal, and has been most undeservedly neglected by both capitalists and the Government; indeed it is only since the advent of the present Viceroy

* 27¼ maunds make one ton of 2,240 lbs.

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that private enterprise has been encouraged, and the writer is in great hopes of seeing this fine field fully developed and yielding its fair share towards the necessities of the Imperial Exchequer.

Summing up the various facts stated in this short and very imperfect paper it will be seen that in an area of some twenty-five square miles no less than 28 feet of coal exists, and the writer is quite sure that a more careful examination than he was enabled to undertake would prove the field much richer than he has described it; and it becomes a matter of surprise that no one has been found to take up the work and bring it to a successful and satisfactory issue.

As before stated, a scheme is under consideration to—

1.—Work the coal deposits.

2.—To construct a light gauge railway from the mines to Baroon, on the Son river, a distance of about 56 miles.

3.—To establish a system of towage on the Son canals, by means of a submerged wire rope and clip drums working on barges; the canal authorities objecting to the use of steam propellers in the canals, on account of the injurious action on the sides and slopes.

Should the project succeed, a large quantity of useful fuel would be rendered available for the numerous and yearly increasing State Railways of India.

Mr. CHARLES HUNTING'S paper "On the Feeding and Management of Colliery Horses" was then discussed:—

The PRESIDENT asked Mr. Hunting if he had anything further to say on the subject of ensilage?

Mr. HUNTING said, that the question of ensilage was being discussed in the agricultural world, and *The Times*, *The Field*, and other papers were constantly publishing letters from men who had used it very largely, and he did not know anyone yet who took any ground in opposition to it, but he could not speak of the advantage unless he had tried it himself. It had been tried in the South of England to some extent and with some success both for horses and cattle, but he believed more especially for cattle. There was great discrepancy between the cost of silos, and if any gentleman wished to try the experiment he must be careful in obtaining estimates, which varied from £40 to £600.

Mr. GREEN asked Mr. Hunting if he had had any experience of mules in pits?

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Mr. HUNTING said, he bought a dozen or two mules after the Egyptian war and tried them in the pits, and the result of the experiment had not been very satisfactory. The mules were very hardy brutes, but were extremely obstinate. Out of eight tried in Ryhope pit four were absolutely useless. The mules were very cunning and could not be got to pull, and he did not think they were likely to be of benefit to the coal-owners, and most certainly not unless got very cheap.

Mr. GREEN—In mines in the United States they use them entirely.

Mr. HUNTING—Yes; Mr. Routledge used them very largely when in America, and it was on his suggestion that he (Mr. Hunting) bought the mules. No greater care could be taken of them, as Mr. Routledge was the superintendent of their work, and, of course, saw that they received fair play; notwithstanding, the experiment had not been successful.

Mr. WILLIAM LOGAN said, in discussing this paper, it may be as well at the outset to draw the attention of the members to the fact that the greater portion of it was published by the author eight years ago. There are certainly a few omissions and some new matter in the present paper, but the author's system of feeding cannot well be understood without referring to his former publication, as in both, taken together, he seems to claim by implication to be the introducer of a certain defined mixed system of feeding horses, and this he (Mr. Logan) wished to call in question.

The materials used in compounding the horse food, however they may be varied in quantity, even to the occasional omission of one of them, are maize, oats, barley, peas or beans, and hay. The author prefaces the publication of 1874 with testimonials to show the date at which his mixed system of feeding came first into operation, and from one of these it is stated as 1851. At page 75 of the present paper, however, it is admitted that it was not until the year 1867 that he recognised that maize was a good ingredient of horse food, and then only after it had been proved beyond all doubt by others; and not until 1868 that he used it. He had, it is true, tried it at South Hetton in 1853, and ascribed its failure, as he usually does all failures of a similar kind, to the want of co-operation of the colliery officials. But one would have scarcely thought that such a shrewd observer as Mr. Hunting would in 1861 have come to the conclusion "that maize was a valuable food for cattle, pigs, and poultry, but not for horses."

It may be, therefore, observed that maize is not one of the grains that he can claim as having introduced in the mixed system of horse feeding, although now in his most approved formula for mixing grains, maize forms 46 per cent. of the mixture.

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As to oats, barley, peas, and beans, it is hardly worth while taking up the time of the members to prove that, long prior to 1851, the latter three were, when found economical, used in conjunction with the first, and that in all cases the peas and beans were split or crushed, bran being occasionally added to give bulk to the mixture.

The author admits, at page 84, that a "mixture of oats, beans, and bran, can be formed capable of meeting any fair muscular waste."

A good deal of the paper is taken up by an attempt to throw discredit on oats as a horse food either alone or in combination. The author gives a good many axioms in the paper, and the first is, that horses, to do their work, must be kept in condition, going on to show (page 63) that "there are two things necessary to produce condition in horses—work and food, or rather, hard work and high feeding." It is further stated (page 64) that "a sufficiency of oats and hay, with plenty of work, will produce condition;" but notwithstanding this admission the author says "the use of oats as a principal article of diet for excessively hard worked horses is very expensive if not injurious," and, in proof of this, adduces a case where horses, although allowed 168 lbs. of oats and 154 lbs. of hay each per week, were "unable for want of condition, or from positive debility, to get the work out." This excessive allowance, excessive even to 16½ hand horses, was apparently insufficient to produce "condition." It certainly does appear that the alteration in the horses requires some further explanation than the mere substitution of a lesser weight of peas, barley, oats, bran, and hay.

At page 66 a Table is given of the constituents of various foods, and it is to be presumed that the Table is compiled from the best of each respective kind, although in that relating to oats, as stated by the author and that given by Mr. R. O. Pringle in his work on the "Live Stock of the Farm," there is an extraordinary discrepancy, which is shown as follows:—

	Mr. Hunting.	Mr. Pringle.
Water	11·8 ...	14·0
Woody fibre	20·8 ...	7·0
Starch, gum, sugar, and fat	52·0 ...	64·5
Nitrogenous matter	12·5 ...	11·5
Ash or saline	3·0 ...	3·0

He (Mr. Logan) agreed with the author that oats "should be sound, sweet, a year old, and their natural weight should be at least 40 lbs. per bushel;" but he did not agree in his condemnation of all foreign oats, as

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the immense number of horses kept in this country could not be fed, even if oats formed only a small proportion of their food, with the short potato oats grown here.

It may be interesting to produce a statement showing the quantities for six months ending December 31st, 1882, not only of oats but of all grains used for horse food imported into and distributed by the north-eastern ports. The statement very well illustrates the magnitude of the subject discussed, and comprises the ports of Newcastle, Tyne Dock, Sunderland, and West Hartlepool:—

	Cwts.		Per Cent.
Maize	246,986	=	44·11
Peas	137,272	=	24·52
Beans	6,133	=	1·10
Oats	169,506	=	30·27
	559,897	=	100·00

This Table shows the imports of grain of the respective kinds for six months, and while it cannot be stated that it is all consumed as horse food, yet practical men, fully conversant with the trade, state that 95 per cent. is so consumed, in the proportions given in the percentage column. He was similarly assured that of the 8,475 tons 6 cwts. of oats imported, fully 70 per cent. were from foreign countries, so that foreign oats enter largely into the composition of horse food in the two northern counties; indeed he knew of one large firm, employing more horses than any one of the firms the author alludes to, that, during the last six months of 1882, used 30 per cent. of the finest quality of undried foreign oats in their horse food, that is, oats which had not been kiln-dried or sulphured, without having had a single case of colic in their stud. One lot of extra fine foreign oats used by this firm was, for the purpose of information, submitted to a thorough analytical test, and the composition of one drachm of these oats, containing 158 corns, selected from the bulk by the purchasers, not the sellers, was 72 per cent. of kernels and 25 per cent. of husk. There are many kinds oats, whether foreign or home grown; and he had been informed that very lately there had been bought and sent to some of the collieries under the author's charge some black Finland oats which were very heavily kiln-dried, so much so that before being forwarded from the dock warehouses they were winnowed and watered to improve their appearance, and by this process they

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gained about 10 per cent. in weight.* Oats of this class, which are bought at a very low figure, make a very cheap horse food, but he strongly deprecated their use.

Before leaving the question of oats he need only further remark that the author, in his Table showing the weight of husk in various grains, again seems to put oats in a very bad light. It has been shown above that a sample of even the despised foreign oats yielded only 25 per cent. of husk, while here short Scotch oats are quoted as yielding 28 per cent., and Elbe oats nearly 39 per cent. of husk. Of course, bad grain of any kind is not to be recommended as horse food.

He quite agreed with the author that barley is a good food along with other grains for mixed horse food, but then it ought to be of the best quality, and members should not be led away by its cheap price in 1881 and 1882. It was only unsound non-malting barley that could be bought for 8d. per stone in 1881, and 10d. per stone in 1882. When barley is used it ought to be sound and good and such as a maltster would use, and when in this condition it is really dearer than maize, whilst it is inferior as a feeding ingredient; take, for example, the present market prices for fair sound average grain of both kinds, say old maize at 36s. per 480 lbs., and barley 34s. per 448 lbs., making maize 12·6d. per stone of 14 lbs., and the same weight of barley 12·75d.

He mentioned this to show that it is unfair to quote unsound barley against sound maize; and also to show that, so long as the price of sound maize does not materially exceed the price of sound barley, maize is the best, where condition in its best sense is looked upon as economy.

It may be taken that, in most establishments where large numbers of horses are kept, the mixing of various kinds of suitable grains for horse food has been long practised, so that if large savings have been effected the savings have been pretty universal.

The only question upon which diversity of opinion may arise is as to the chopping and mixing of hay with the grains, there being an agreement that hay is necessary. There also appears to be a difference of opinion as to the best method of giving the chopped hay; some preferring to mix the grains and hay in one bag before they are sent into the mine, and others sending them in separate bags, in which case the chopped hay is put into the manger first and the grains then added, and slightly mixed with

* It may be as well to observe here that Mr. Hunting states that these oats were returned as not according to sample, and that the seller had to pay the railway dues and all the expenses attending loading, unloading, storage, etc., etc.

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the hay. He (Mr. Logan) had a preference to giving long hay, and that in a separate rack from the grains, and in a carefully conducted establishment there is as much economy with the one system as the other, but he was afraid that ultimately it must be left to individual judgment, as it is impossible to elicit information from the horse as to his taste in the matter. If, however, it be taken for granted that a man had a certain quantity of fish, flesh, and pastry, with their concomitants, cooked for his dinner, and was told that a certain proportion of each would sustain him in condition, he would no doubt accept them without question and eat them in the ordinary way; but if, without altering the constituents or their proportions, they were all mixed together, he would think it anything but a savoury mess, although in process of time he might be able to take it in default of other means of subsistence. He entirely agreed with the author in his remarks on the value of green food.

On pages 90, 92, and 93, the author gives some tabular statements as to the cost of feeding and the savings effected; but, as he himself says at page 62, "tabular statements of the cost of feeding show absolutely nothing save by comparison with others, and a comprehensive estimate should include not only the cost of food, but the cost of horse flesh and the amount of work done." The amount of work done is the real test, and this the author has attempted to show by giving the weight of coal drawn, which is entirely misleading, as coal can be brought to the bottom of the pit and to bank without any horses. The only thing which the Tables appear to be intended to show is the great saving effected by a mixed system of feeding, but this is illusory. If a system of mixed feeding had been adopted at the collieries under the author's charge and at no other, then he could have understood this saving; but as he (Mr. Logan) has shown the system of mixed feeding is nearly universal, there can be no saving at any of the collieries enumerated over other large collieries. As well might a colliery viewer prepare a Table showing the difference between the method of leading coals underground now and that prevailing 60 years ago, and claim that at the collieries he managed he had effected an exceptional saving of thousands of pounds, ignoring the fact that others had adopted the improved haulage also.

If the author had given the average cost per week, or per year, of the various sizes of horses and ponies, averaged through the whole of the collieries under his charge, it could have either been admitted or controverted that other large establishments with their management could or could not do equally well.

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There are plenty of other large establishments where the system of buying, of feeding, and of working their horses and ponies will compare with any the author quotes.

It is the usual practice, as the author will allow, where large numbers of horses are owned by one firm, to employ competent veterinary surgeons, and buyers, and inspectors of their stud, and the highest attention is given to the purchasing, preparation, and distribution of the food; and they will learn with astonishment and doubt the assertion that there "are several hundred ponies in pits, not two years old, that have been underground a year."

The author, on page 63, remarks on the practice of buying horses and ponies from a dealer one day and putting them to excessive work the next. This, so far as he (Mr. Logan) knew, was not the practice, and others of more experience would agree with him. The author then goes on to wonder that "such a palpable, common-sense matter should be so often overlooked by the managers of collieries;" he also wondered, and wondered where it occurred?

This is followed up by a statement on the same page, to which he must, as a colliery manager, give his unqualified contradiction, and he hoped he would be supported by every colliery manager worthy of the name. The statement is—"the still more common practice of working underground animals twenty to forty hours' shifts without their harness being taken off."

He had known the Northumberland and Durham pitmen for over twenty years, but he was not aware that they "ate daily from 12 to 24 ozs. of flesh food." About 8 ozs. would be found a very fair and liberal average.

In conclusion, he had to draw attention to a Table on page 94 as to the average length of life of pit horses, which he thought might be valuable for comparison. He was, however, astonished by the first given, viz., "Bearpark, 12 years," knowing that this colliery was not commenced to be sunk until 1872.

The paper might or might not be valuable as a contribution to the Proceedings of the Institute, but he thought the author ought to have recorded the fact that to a very large extent it had been already published; and, in his opinion, the whole of the previously published paper might have been given to the Institute with the preface and testimonials, and the new matter added as an appendix, even if it had required a few more testimonials of more recent date.

The PRESIDENT thought Mr. Logan had misunderstood the figures about Bearpark. Mr. Hunting did not mean that the horses had been

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there twelve years, but that their average length of life had been twelve years. Whenever the colliery commenced the horses must have had some age when they were brought there.

Mr. A. L. STEAVENSON asked whether it was not better to give hay in the state in which it could be selected, and the bad taken out and thrown away, rather than give it chopped up, when its quality could not be so easily ascertained? As to the woody fibre mentioned in the case of oats, was it entirely useless as food? His impression was that it might keep other food open, so as to allow secretion to take place, and so was good, although not of a feeding character. Some horses in Cleveland had been referred to; they were large powerful horses, and would fetch in the market about £70 each. Pit horses were going 8 hours, but these horses were going for 7½ hours; although they did not go so fast or travel the same distance as pit horses, he had no doubt they did as much work. His impression as to feeding was that crushed English oats mixed with beans, and good uncut hay, formed a class of food impossible to beat. A veterinary surgeon said that maize given to horses was injurious, and that in fact several horses had died from the effects of it. That was the experience of Mr. Barker, of Middlesbrough, who had charge of perhaps all the horses in Cleveland. Oats alone were not good feeding, but mixed with beans and peas they formed a kind of food that could not be surpassed.

Mr. MAY said, he agreed with Mr. Hunting in regard to the chopping of hay. At his place there were between 300 and 400 horses. Formerly the hay was not chopped, and there was great waste. Anyone who had observed the uncut hay go down the pit in bundles on a wet day, and now saw the cut hay go down in bags, would appreciate the difference, and if they examined it in the hay-board would be satisfied that chopping hay was as great an advantage to the horse as the saving in cost at the end of the year was to the owner. He was formerly a non-believer in the chopping of hay, but after three years experience he thought it a great advantage to the horses and a great saving to have hay chopped.

Mr. E. F. BOYD—Is the chopped hay given separate from the other food, or is the food all mixed together?

Mr. MAY—A little of the chopped hay is put among the oats to prevent the horses bolting their food.

Mr. BIRKETT (Farm Manager to Messrs. Bolckow, Vaughan, and Co.) said, that after twenty years experience they found it best to mix the chopped hay with the corn. He would like to have more information about the average life of colliery horses. Mr. Hunting stated that

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in some cases it was twelve years. If that period was divided by four, it would, in his opinion, come nearer the mark, unless one-third more horses to do the same work were employed. At their collieries maize had been used for a great number of years, although Mr. Barker, the veterinary surgeon in Cleveland, always condemned maize. Maize was best mixed with other food. One speaker had said that because hay was chopped all the bad hay would be used. That was not the case, as the hay was sorted before it was taken to the cutter.

Mr. STEAVENSON—Mr. Barker's opinion, after opening a horse which had been fed on maize, is that maize is not the best food; and this opinion from a man like Mr. Barker is valuable.

Mr. BIRKETT—Maize mixed with other food has been the cheapest and best food for horses, but in the past year it has been too dear.

Mr. BURNETT said Mr. Hunting, in his paper, stated that in order for hard work to be performed by horses food containing a heavy percentage of albuminoids must be used. He agreed with Mr. Hunting's system of feeding. He could not say that he (Mr. Burnett) spoke from experience; but from the theoretical instruction he received he learnt that the food of young growing animals should contain a sufficient quantity of nitrogenous matter in order that new tissues might be formed; but that animals of mature age should, to perform work, be fed, like a steam engine in proportion to the work done, and then fat and starch were required in the food. He had corresponded with a gentleman on this subject who was intimately acquainted with Rockhampstead, where Mr. Laws had conducted the most valuable experiments of the age in connection with the subject, and that gentleman seemed to be of the same opinion as himself in regard to the theoretical part of Mr. Hunting's paper. He agreed with Mr. Logan that Mr. Hunting seemed to be rather hard upon oats. Mr. Hunting gave 25 per cent. of fibre in oats. The works he had consulted and the lectures he attended at Cirencester gave between 10 and 11 per cent. of fibre. It was possible, however, there might be some misunderstanding as to what fibre was. In the books he had consulted it meant the undissolved fibre after treatment with acid. He might mention that in the German experiments it had been found that a considerable percentage of albuminoids was required to keep an ox in condition.

Mr. CLEMENT STEPHENSON, Veterinary Surgeon, said he did not come to the meeting prepared to say anything upon the subject, as he had not read Mr. Hunting's paper. He believed all hay ought to be chopped, and he was quite sure it would be a great saving. He did not know

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that there was much nutrition in the hay, but it was useful to fill the large intestines; and he even thought it would be a proper thing to mix a certain quantity of straw with the hay in chopping. No bad hay should be chopped, and all dirt and dust should be taken out of the hay before giving it to horses. He had not much faith in maize. When maize was cheap it would do to mix. Horses for colliery work wanted a large amount of beans and peas; they wanted a large quantity of nitrogenous food to help them in doing hard work; and he did not think they got that in maize. For hard work oats were required. Oats, beans, peas, and especially bran, were a good mixture.

Mr. T. W. BENSON said, that in regard to Mr. Hunting's statement as to ponies under two years old being sent underground, he came across a paper by Professor Brown, of the Veterinary Department of the Privy Council, which confirmed much that Mr. Hunting had said—that rough forest ponies lost their aspect of colthood very soon, and it often happened that a yearling was mistaken for a five-year-old, and a two-year-old for a six-year-old.

Mr. F. STOBART said, that at the colliery he had been connected with he had had some experience of cutting and crushing. Previous to five years ago the hay was sent down uncut, and the horses were fed on oats and a few peas. At that time a new system was started with considerable difficulty, in the face of much prejudice. Under the new system the hay was cut, and the horses were fed on maize and beans or peas, and sometimes both; and he found that pretty equal if not greater work was got out of the horses. The overmen started the new system as non-believers; but they were believers in it now. The stud was in a better condition, and there was a great saving in cost. When maize got to a higher price they discarded using so much of it; and he found that he did not get from the horses the work he had previously got. He then put on nearly the amount of maize he had used before, and he got good work again. About 45 per cent. of maize, 30 per cent. of oats, and 25 per cent. of peas or beans, as the case might be, was the present food, and he thought the best results were got from that mixture.

Mr. W. F. HALL said, that six weeks or two months ago Mr. Hunting commenced to feed the horses at the colliery on oats, beans, and peas, as maize was at too high a price. He (Mr. Hall) complained to the colliery officials that they were not getting the work out, and the officials said since the maize had been discontinued the horses had lost condition, and could not do their work as before; they were less lively and energetic. He wrote to Mr. Hunting that, whatever the cost might be, he must return to maize and keep the horses in proper condition.

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Mr. HUNTING said, that his system had been strongly opposed by many men, and frequently by those who should have encouraged and supported him. Two or three statements had been made by Mr. Logan, which he (Mr. Hunting) would have been pleased if he had left out, since they were unaccompanied by any references which would allow their accuracy to be tested. He was glad to see, however, that he had alleged nothing against the three leading principles laid down in the paper, viz.:—(1) The importance of nitrogenous foods. (2) The quantity of each ingredient used, to be governed by the price per stone in the market. (3) The absolute necessity of using large quantities of corn for feeding, instead of hay, for all horses heavily worked: three points that explain nearly all the advantages of economical feeding. Again, Mr. Logan says, "the mixing of suitable grain for horses has long since been practised, and was not suggested at the places over which the author had control, and that the saving pretended to have been effected is 'illusory,' because other large collieries had adopted mixed food feeding, or implied that they had done so, before his system was published." In 1851, he took much trouble to find one place in the counties of Durham and Northumberland, where they used cut hay and mixed food feeding, but he did not succeed in finding it, either amongst collieries or any other large horse establishments, and he visited nineteen-twentieths of the whole. If Mr. Logan knew where it was used, why did he not give the name of the place, the quantities used, and the cost per annum of the stud? That would have been useful information, which could be tested. In 1853, 1856, 1860, and 1872, he (Mr. Hunting) was permitted to publish the results of the feeding at South Hetton and Murton Collieries. Up to the first-mentioned date, he did not believe it was done anywhere in the North of England, and he challenged Mr. Logan to give an instance of it. Even had it been so, it only touches the fringe of the subject, the three important principles laid down in his paper being:—(1) The selection of the kind of grain used. (2) The relative price of each per stone in the market. (3) The quantity of each kind that is most economical and gives the most blood to the animal for the least money. Again, Mr. Logan says, "if the author had given the average cost per week, of the various sizes of horses and ponies, it could have been compared with other collieries." This was done in every case referred to in the reports, and the saving effected in every case is given upon the same sized animals as were on the colliery the year before he took charge, as is fully explained on page 89. He could give twenty cases in which he had seen ponies in pits, not two years old, every tooth in their head milk teeth, and yet they had been twelve months underground. Viewers and others should take more care to see whether horses were young, as a matter of economy.

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He was glad to have heard what Mr. Benson had said; for it was a peculiar fact that ponies of twelve or fifteen months old had often been mistaken for older animals by him until he saw their mouths. When he examined their mouths carefully he did not find a single permanent tooth in them; and some of the incisor teeth were scarcely out of the gums. The greatest novice knew whether an animal was one year, or four years, or three off; but good judges of horses had often been deceived by taking a two-year-old for a five-year-old, and a five-month-old for a two-year-old. At two years old the mouth was full; there were the twelve incisors all alike. At five years old there were twelve incisors, and all alike; but in the one case they were milk teeth, and in the other case they were permanent teeth. If the animals had been fed on heather, as many animals were on mountains, the teeth became brown in colour, and it was sometimes difficult to say whether they had permanent or temporary teeth. Mr. Logan was deceived in supposing that any man could tell a five-year-old mouth. No man could be mistaken in a two years off or three years off, or four years off, or rising five, because in those periods the mouth was never perfect. Mr. Logan had spoken about oats, and had pointed out a seeming inconsistency in the percentage of husks given by him, although the amount given, 25 per cent., in Petersburg oats of 40½ lbs. natural weight, accords with that in the test quoted by Mr. Logan. This gentleman evidently supposes that the best oats should have the smallest proportion of husks, which is not so, as in no case can the same amount of husks be obtained from the light Russian oats as upon the shortest Scotch potato oats, supposed to be the best oats grown. Mr. Burnett and Mr. Logan had each spoken about the husk of oats. He thought Mr. Burnett's remarks were apparently contrary to the statement in the paper, because that gentleman had taken the woody fibre as separated from the oat husk. If they referred to his paper it would be found that he gave the result of experiments with various grains with the entire husk, not chemically separated. Mr. Logan seemed to think that he (Mr. Hunting) had absolutely put down the husk of Scotch oats as something enormous, but it was a fact that foreign oats gave less husk than the best Scotch oats. The St. Petersburg "needles," as they were called, were the lightest oats, and had the smallest amount of husk. This was tested by him more than a quarter of a century ago. But that proved nothing as to the value of foreign and English oats as a feeding material. Mr. Logan thought the oats were not kiln-dried. Everyone knew that nineteen-twentieths of all the oats that came to England were kiln-dried. Since the farmers on the shores of the Baltic, from whom a large portion of

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the oats came to this country, had been growing their oats from Scotch seed, the oats had been greatly improved, especially in weight. A few years ago the weight was about 35 lbs., and now it had come up to 40 lbs. and 42 lbs. per bushel. The reason why they got so much more husk in good Scotch oats than in Russian "needles," he (Mr. Hunting) thought, was the fact that foreign oats were kiln-dried, and when the husk was separated they got the internal film separate from the foreign oats, but it adhered to the husk of the Scotch oats. Another gentleman had said he (Mr. Hunting) was hard on oats. In his paper he said "if the choice of grain is limited to one variety only, oats are the best." That did not seem to be very hard upon oats. "If cost is no object oats and bran form a food simply unobjectionable." That was not very hard upon oats. "But, as the following Table will show, oats vary considerably in value;" and he (Mr. Hunting) then showed the weight of husks. His whole paper was based on cost, and not upon what was best. If they could get a material at 8d. or 9d. a stone which would answer their purpose and enable their horses to do the same amount of work, where would be the policy of using materials which would cost 14d. or 15d. a stone? Mr. Logan said all collieries used mixed food fifty or sixty years ago. In 1849 none in North Durham, and not a single colliery in Northumberland used mixed food. Let Mr. Logan name the colliery which used mixed food fifty or sixty years ago. He (Mr. Hunting) did not know one, and he had made as many inquiries into the feeding of horses as anybody. There were no large establishments, collieries, or other works in the North of England which used the mixed system of feeding fifty or sixty years ago. Now, in 1850, it was common enough when he was a boy to use cut food and mixed food in the South of England, but not in the North.

He was in the presence of a large number of colliery managers and viewers, and he would ask them whether it was common or uncommon to purchase horses and ponies and put them down the pit the next day, or within two or three days? And whether a score, or even one hundred cases could not be given to establish what he had seen with his own eyes. Then again, with respect to excessive over-working, it would be clearly out of place, in a discussion like this, to name places where cruelty had been practised, but he distinctly averred that he knew a case in which two cobs had been worked from Monday morning till Saturday night without having had their gear taken off or having been brought to their stables. He admitted that these things were not done now to anything like the extent they were a few years ago; but any one who knew anything

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about collieries knew it was common. They paid to the extent of hundreds and thousands of pounds loss often from the stupidity of purchasing animals off soft food and putting them to the heaviest muscular work in three or four days. As to the decreased number of deaths of horses, he imputed most of the advantage, not to feeding or management, but to the "case book." If he took no more notice of the deaths of horses than by merely speaking about it, the horses under his charge would be the same as others he had no doubt; but there was not a colliery with which he had to do but had a book in which were entered the name and colour of the horse or pony and the name of the driver, and the reason why it was off work; and they could understand what the effect was. Every man, from the resident viewer down to the putters and trappers, knew that the case of every animal abused would be brought before the head viewer and be investigated. That was why the losses in his studs were so small. Some member had said that cutting hay was objectionable, because they might cut the bad hay as well as the good, and the man would not be very wise who did not separate the bad hay from the good before it was cut. He thought Mr. Logan, like Mr. Steavenson, did not much approve of maize. Nobody could be more opposed to maize than he formerly was; he was opposed to it at first, and had good reason for it. Mr. Logan thought there was not much credit due to him because he only followed the example of others. In his paper he told them that maize was used by everybody. He did not claim that all that he had stated came from his own head; he had used the labours of others. If any man had anything to tell him he was extremely glad to hear it, and to try whether it was true or not; if true he was thankful for it, and if untrue he discarded it. In the Cleveland district, there were a great many persons who had an objection to maize, and if asked why, they did not know. It was said that Mr. Barker had found that maize killed the horses, but horses died before maize was introduced, and the President had a colliery where there had not been a death from disease of any kind for five years. That did not very much look as if maize killed horses. At Prudhoe pit there had not been a death from disease of any kind for seven years come April. Mr. John Liddell asked, if all the horses at bank could do without oats, why they were necessary for those in the pits? He (Mr. Hunting) said he did not dare to make such a change, because if a stone fell from the top and killed a horse, it would be said the maize did it. For six years come April there had not been oats bought for the three collieries at Prudhoe and Mickley until six or eight weeks ago, when maize was up to 44s. It would not have been wise to have bought maize

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at 44s. when oats could be got at 26s., and hence for a time he almost discarded maize at the collieries; reducing it from 40 or 50 to 10 per cent., and then there were complaints from Ryhope, Haswell, South Hetton, Ouston, and Cowpen that the horses did not do their work so well. No one who had tried it could arrive at any other conclusion than that, as an adjunct to oats and beans, there was no food so cheap, and no food more calculated to correct the digestive function of animals, ever used in Britain than maize. The percentage of colic cases was 200, 300, and often 500 per cent. less when maize was used in the proportion he recommended than when not used. Inflammation of the bowels was almost unknown at collieries where 40 or 50 per cent. of maize was used. Twenty or thirty years ago, when maize was not used, there would be hardly a colliery which did not lose one or two horses a month from colic, and now they did not lose one in a year. And yet it was said that maize was objectionable; and when people were asked their objection to it, they replied that it produced a tendency to greasy legs. If it had that tendency it would be a strong objection. Out of two hundred animals at a colliery where maize was largely used only one animal had greasy legs. He did not think it necessary publicly to name the colliery, but he would tell it to any person who wished to investigate the truth of the statement. There was no absurdity, no thoughtless statement, that was not grasped at and supported at collieries in the North of England about this system of feeding. There was a colliery he had never been on and the stud of which he had never seen, and all he had to do with it was to purchase the maize and peas, the colliery owner and viewer regulating the feeding. He (Mr. Hunting) was very anxious to know how these gentlemen would succeed in carrying out the system of feeding without his (Mr. Hunting's) assistance or oversight; but afterwards the gentleman gave him the result of three years' feeding, and he (Mr. Hunting) was very much astonished to find that, with all the economy and saving he had stated, his (Mr. Hunting's) cost was £2 to £3 a year higher than the highest year of that gentleman's cost; also for three years this system of feeding was carried out in a large stud under a viewer at a colliery, with which he (Mr. Hunting) had nothing to do, and the cost never reached the sum of £20 per head. He apprehended that Mr. Logan would have some difficulty in finding a colliery in Durham or Northumberland where they could feed their horses on less than £20 a year. That was not his (Mr. Hunting's) doing, but it was the result of his system, tried by some one else; and this was the strongest proof he could give them of its value.

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Mr. Clement Stephenson agreed with him as to cut hay, and so did everybody who had tried it; but Mr. Stephenson did not like maize. A great many more did not like maize. He had stated the results of the use of maize, and had given the names of the collieries and of the owners, and anyone could ascertain whether what he had stated was true or not. What was their objection to maize? As he had already said, some people thought it had a tendency to cause greasy legs; and if it was proved that it had not that tendency, then they would object that maize intensified the odour of the fæces, which he admitted; and so did wheaten bread. If the use of maize produced sulphuretted hydrogen instead of carburetted hydrogen, then why not leave off eating wheaten bread? The odour did not, however, come from the skin of the animals, but from their fæces. This was about on a par with all the objections to maize: they did not know why or what they objected to, and the worst they could say against it was that it smells. If the collieries of England could save £70,000, £80,000, or £100,000 a year by the use of maize, they surely could put up with this. Had it not been for the introduction of maize into this country colliery horses would have cost £12 a head more a year to keep. When oats were scarce, as they were two years ago, and at a high price, about 5,000,000 qrs. of maize came into this country, the greater part for horses' food; and horse owners not only gained in its cheapness for feeding horses, but also because it reduced the price of every other material used for feeding horses. As to barley, it was not its quality, but the working of the Beer Act that had to do with its low price. Up to the time of passing this Act, nineteen-twentieths of all the barley grown in England was used for malting; but now sugar, treacle, foreign barley, maize, or anything could be used by brewers. Mr. Logan told them that it was because the barley was bad that it was used for feeding horses. Formerly 4,000,000 or 5,000,000 qrs. of barley was used for malting purposes, and not a quarter part of that quantity was used now; the result was that barley was reduced in price, and good feeding barley came down to 24s. a quarter, a price never before known. Men who are accustomed to the trade know that barley, not suitable for malting, is not necessarily one penny worse for feeding purposes than a good sample of malting barley, if of the same natural weight, because it would give quite as much food to the horses, yet frequently costing 8s. to 12s. per quarter less money. In malting, the essential part is that all the grains should germinate at the same time otherwise a large portion of the "saccharine" matter is lost in the brewing, but in feeding it is a very different matter and of no moment, so long as the barley is in fair condition, clean and sweet, and if

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the same weight, it is of equal value to that used for malting, and yet Mr. Logan recommends his hearers to give 9s. to 12s. per quarter more for one kind than the other. Mr. Burnett had referred to the theoretical part of the subject. Up to 1866 Liebig had shown it was essential to use highly nitrogenous food to replace the consumption of muscle used up in hard work. This theory was generally accepted all through Europe and America both by chemists and physiologists up to 1866. In that year Fick and Wislicenus disputed it; and in 1866 these two Germans, made the ascent of an Alpine mountain in order to test it. They emptied their bladders at six in the morning, and carefully analysed the urine; they preserved every drop of urine made in the eleven hours route up to the mountain peak, and abstained from any kind of nitrogenous food whatever. They said that, if Liebig's theory was right, they must undoubtedly have an increased excretion of nitrogen from the dissimulation of the tissues of the body. They analysed carefully the urine taken from each during the ascent, the analysis being within a few decimals, and found there was almost an imperceptible increase of nitrogen. They did that on the day following their descent from the mountain, and the result gave rise to a great discussion among chemico-physiologists. Dr. Fick thought it upset Liebig's theory; and they said also, "what can be clearer than the fact that there was no increase of nitrogen in the urine from the dissimulated tissues during that time." Many in Germany and in England became delighted, and every scientific institution was exercised by this discovery that Liebig was wrong. An American, Dr. Austin Flint, perhaps the greatest living physiologist, was however, in favour of Liebig's theory, and, with others, spoke on his behalf. In 1870, Weston, the great pedestrian, commenced in New York his great walk of 400 miles in five days. Several members of the medical profession and chemico-physiologists thought that was an admirable opportunity to test, beyond doubt or cavil, whether Liebig's important theory was correct, and a Committee of ten or twelve of the greatest scientists in the medical world was formed to test the new theory when Weston was performing this great muscular exertion. By this time it had been discovered that it was not the day that the exercise took place that the nitrogen in the urine was so largely increased, but that it extended over two or three days some time after; and that if the two Germans had taken the result of the disintegration of the tissues and the development of nitrogen after the ascent, they would have found that absolutely 42 per cent. more of nitrogen had been eliminated than had been taken into the system. The result was verified

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during Weston's muscular exertion, 45 and even 50 per cent. more of nitrogen being eliminated from the body than was taken in the way of food. For five days before the experiment every particle of food that was eaten by Weston was weighed to a grain, and every particle of fæces and urine made was carefully analysed, both chemically and microscopically. During the five days of his walking the same thing was done, and the experiment was continued for five days after the walking; and the result proved beyond doubt Liebig's theory that the consumption of muscle was absolutely going on, in a way contrary to Mr. Burnett's theory. During four days 100 grains of nitrogen were given in the food, while 197 grains of nitrogen were extracted from the urine, or nearly cent. per cent. more deterioration of tissue took place than had been taken into the body, proving that the theory of Liebig was perfectly correct. But putting aside theory, chemistry, and physiology, practise gave quite as decisive results. Brassey probably knew nothing of nitrogenous or non-nitrogenous foods, of albuminoids or hydro-carbons, but he knew that men fed on beef and mutton could do more work than when fed on bread, rice, cabbage, potatoes, carrots, turnips, radishes, onions, etc., as were his French and Italian "navvies," and within three months of these men getting beef and mutton, he (Mr. Brassey) found that they could do, and did, as much work as his "English navvies." Colonel Apperley, or "Nimrod," used constantly to say, when they were in a two hours run without a fault, "Now we shall see who has the odd beans." Probably he knew nothing and cared less about the chemistry of foods, but he knew where violent muscular exertion was long continued, that those who had the beans would last the longest in the run. Again, whoever heard of great "athletes" whilst training, living on hydro-carbons, as rice, sago, bread, potatoes, carrots, turnips, and fruits; but why should they not if Mr. Birkett's theory is correct? Everyone knows that, to get men fit for great muscular exertion, plenty of beef and mutton are essential; whilst fruits, pastry, and light vegetables are little used; and he contended that this mode of feeding all great "athletes" and "hunters" shows conclusively, that in hard work nitrogenous foods are more essential than hydro-carbons, so that both in theory and practise, the principles laid down in the paper are correct. With regard to ponies being put to pit work directly after being bought he would remark that there are many things which might be said and proved too, but which it would not be wise to print. He preferred to leave the matter where it was, except to say that the person who so strongly objected to this statement of his at the meeting, did, within the last year, buy six ponies off grass

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feeding, and within a week put the whole of these three or four year old ponies down the pits, although they had never seen or tasted hay or corn up to the day of purchase. So much for inconsistency. Mr. Logan says the amount of work done is the real test. He granted that this was the important question, and in that portion of his paper on "Work," he attempted to show this by giving the distances the horses and ponies travelled at several collieries, and by the horses in this city, purposely that others might compare the work of their horses with that of those under discussion. Mr. Logan ignored this portion of the paper altogether, and says the weight of coals drawn, which was given as a measure of work done, was entirely misleading. The fact is, he had nowhere in the paper mentioned one word about the quantity of coals drawn, but at page 99 he gave the miles travelled by many of the horses at six or seven collieries, but not a word as to the quantity of coals drawn. The only place where quantity is mentioned is in the 21 years' tabular statement relating to South Hetton, which has nothing whatever to do with "Work," and was given only at the request of the owners, who asked for the return to be made. Had he wanted to shelter himself as to the economy of his feeding, under such returns of coals drawn, he should have made use of it, by showing that the South Hetton and Murton Collieries drew over a million tons of coal last year; but he could have gone further than that, for he had a letter from Mr. Heckels, viewer of Castle Eden Colliery, infinitely stronger. Mr. Heckels, in a letter of September 27th, 1882, says:—"The health and capacity of our stud for work will be best shown by informing you that we drew 100,000 tons of coal more last year than has ever been drawn at this colliery, and with no increase in the number of the stud. The health and condition of the animals has been all that could be desired." As work done is Mr. Logan's test of the value of feeding, he would briefly show what had been already done, and in both cases by figures not his own, by which the members of this Institute could, for themselves, test the accuracy of the comparison, because the distances in Cleveland, weight of loads, and the gradients were taken by the managers of three of the principal stone mines in that district, and in the case of the Corporation horses in this city, the streets were measured and gradients and weight of loads taken, by the Corporation officials. In Cleveland most of the horses were 16·1 to 17·0 hands high, and the loads were a little under 2½ tons, drawn over a gradient, averaging under 2½ inches to the yard, on iron rails. The greatest distance any one of them travelled per day was under seven miles, and the average under six miles. The Corporation horses of this city travel seventeen to twenty-

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five miles per day, their loads are 2¼ tons to 3¼ tons, the former with night soil, the latter with the water carts. They are the largest and heaviest breed of horses in this district, weighing from 14 to 17 cwts., standing 16·2 to 17·0 hands, and working 10 hours per day. Many of the streets up which the loads have to pass are 4 to 5 inches to the yard gradient, and so excessive is the labour of these "night horses," that there is not a single man in the whole city, who lets horses for hire, that will allow his horses to be put on the "night work." He had made minute inquiries in nearly all the large towns and cities in the kingdom as to the work of horses, and had never found any horses doing within "one-third" of the work that the horses of this city have been doing during the past six years; yet the cost of all provender consumed in 1881-2 was only 12s. 2d. per horse per week, or 9s. per week less than when fed on the old system of long hay and whole oats, bran and a few beans; and, he might add, that not a single death took place in the whole stud, numbering 66, during that year, whilst in the Cleveland stud there were 22 deaths out of 92. The Newcastle horses had 50 per cent. of maize with their other food, the Cleveland horses had none. A finer or more healthy stud of horses than those belonging to the Corporation of Newcastle cannot be found in Britain. This does not look like maize killing, or being unfit food for hard-working horses. This "work test," as given above, ought to be interesting to Messrs. Logan, Barker, and Steavenson (of Cleveland), showing that the food of the Corporation horses costs little over half the money, and that for years they have done, and are doing still, more than twice the distance and twice the work, because the Corporation horses draw their loads over granite-laid streets and macadamized roads, as against those in Cleveland on iron rails. As this is an extremely interesting test case, and can be proved by any gentleman who cares to take the trouble, he would give the names and figures to the President and Secretary for the information of any gentleman who might require them. He had purposely chosen the horses of Cleveland to compare with those of the Newcastle Corporation, because they were nearest in size, the latter, however, being much the larger and heavier of the two. Great as is the difference between the cost, work, and losses of these two studs, it is not any greater than what is found in comparisons he had made amongst colliery horses. In conclusion, he would ask Mr. Logan to give him any instance of two collieries, where the old system of feeding is carried out, equal to Prudhoe and Bearpark Collieries, where, in the former pit, not a single death has taken place from disease of any kind for seven years come the 18th April this year, and where no oats have been used for six years of that period. At Bearpark Colliery, not a

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horse or pony has died from disease of any kind for 4¾ years ending 1882. It does seem marvellous how such men as Mr. Steavenson, Mr. Barker, and Mr. Logan can believe cut hay and maize to be injurious to horses with such results as these, results which any of them can test by simply writing to the viewer, or asking permission to see the "case book" in which every death is recorded, and what produced it.

Mr. BIRKETT said, that as representing the largest coal-producing firm in Great Britain, his experience caused him to deny *in toto* Mr. Hunting's very sweeping assertion that generally horses were sent into the pit direct from being purchased from dealers or farmers.

The PRESIDENT did not understand Mr. Hunting to say it was the universal custom, but that it was very often done; ten or twelve years ago it was a more general custom. Where horses are managed on a system like Mr. Birkett's it would not be likely to be done.

Mr. LOGAN assured Mr. Hunting that there was nothing personal in his (Mr. Logan's) remarks. He to a great extent agreed with Mr. Hunting's system. He would repeat what he had already said, that in 1881 and 1882 barley, owing to its unsound condition, was sold cheap. The same cause that brought down the price of barley in 1881 and 1882, according to Mr. Hunting, was in force yet; and good malting barley was being sold in 1883 in the North of England at 34s. That was the basis of his calculation. Let them have the cost of feeding ponies and horses of various sizes, and then they would know what they were doing. He was not so ignorant as not to understand the difference between woody fibre and husk, and in his remarks he was careful not to mistake one for the other.

Mr. STEAVENSON proposed a vote of thanks to Mr. Hunting for his paper.

Mr. BOYD seconded the motion, which

Mr. LOGAN cordially supported.

The PRESIDENT said, that having had all his horses under Mr. Hunting's system for many years he could bear testimony to its practical utility, and he suggested that those who did not believe in it should try it for a year. He believed he was right in saying no colliery had, after trying it, given it up. It was not the case that horses selected good hay. If a lot of hay was put into the manger the horse would throw out good with the bad. If they supplied a horse with the very best hay he did not think the horse would eat it all, but would throw some of it out; and if they gave it bad hay, the horse would eat some of it.

The motion was agreed to.

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Mr. W. J. BIRD'S papers on "The Comparative Efficiency of Non-Conducting Coverings for Steam Pipes" were discussed.

The SECRETARY stated that he had been requested to ask Mr. Bird if he had ever tried to utilize air as a non-conducting medium. He asked if Mr. Bird had tried to what extent air acted as a non-conductor, and could state the result of any experiments he had made? If a current of air passed through the space between the pipe and its covering, the air, of course, would be anything but a non-conductor; but if they could obtain any knowledge as to how and to what extent it could be made a suitable material as to cheapness and utility, it would be very valuable information.

Mr. BIRD said, they knew that air was a pretty good non-conductor, at all events in a dry state; but heat was easily transmitted from the air. He failed to see how an air-course round steam pipes could save heat. The air would get hot, and the pipe and the air would give heat to the outside. Since the date of his paper, the subject of non-conducting coverings had occupied his attention a great deal, and he had not come to any conclusions other than he had already advanced. His further experiments had only confirmed those previously made by him. On comparing his last paper on the subject, some discrepancies would be found in the tables of cost, which was due to the revised table of prices; but there was no discrepancy in the effect and the heat loss, and the consequent loss of horse-power. In prospectuses and advertisements very much larger savings of heat were claimed than could be relied upon. In one case, no less than 25 per cent. of saving was claimed. That was impossible. In the case of a vertical boiler, entirely exposed to the air, the loss due to the radiation of the service was about 15 per cent. The best non-conductor he had tested saved 14 out of that 15 per cent., leaving only 1 per cent. of loss still remaining, which 1 per cent. he thought they would allow to remain, as they could not very well get over it.

Mr. J. A. G. ROSS said, that Mr. Bird had sufficiently answered the suggestion thrown out by Mr. Bunning; but there was no doubt that air was the best non-conductor, very much better than anything Mr. Bird had tried experiments with; but the substances that had been tried, more particularly silicate cotton, had the power of resisting that action which Mr. Bird spoke of, namely, the convection of the gases. Silicate cotton had the power of retaining a very small quantity of air, divided by a very thin covering of that material, and hence in this way the heat was interrupted, not only by preventing the circulation of the air, but by the repeated resistances from one surface to another, and this was borne out

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by the experiments. As to the remarks of Mr. Bird about 15 per cent. of heat being lost, they must not forget that a very large proportion of heat passes away, not merely by radiation, but by conduction. He remembered the case of a boiler at the Tynemouth Exhibition; when the shed was open, and the wind blew in from the sea, they could not get steam up; and this continued to be the case till the place was boarded up. That was the effect of the wind blowing upon the boiler. He thought it would be more satisfactory if the persons who were interested in these various substances had some opportunity of seeing the experiments when they were going on. He thought it was scarcely fair to a proprietor of any substance to try it without his having an opportunity of being present. He believed Mr. Bird had not done justice to silicate cotton, because he tried it only by tying a string round it. That was not a fair way, as it wanted a thin covering to keep the air out. He had been informed that Mr. Bird had been acting in some way as agent for one of the substances; and they should have had an opportunity of joining with him in the experiments, as a matter of justice to those interested in the other substances. This was an important subject, not only as regards economy in boilers, fuel, and labour, but also in supplying dry steam, which was perhaps most important, for although there was a percentage of loss indicated by the temperature, yet condensation carried water to the engine, which was more injurious to the working parts. He recommended everybody who had boilers to have them, and the pipes also, covered.

Professor LEBOUR said that when the first paper was read he made some remarks regarding conductivity upon certain substances, which he believed had been misapprehended. He would like to put them in another form. Upon the table were some specimens of so-called silicate cotton, and they would illustrate his remarks very well. Silicate cotton was an artificial form of pumice. They knew that the conductivity of pumice was among the lowest; and the looser the pumice was, the worse was the conductivity, and that came from the extreme division of the air. In one specimen the material was packed tight and glazed, and there was not the least doubt that by so doing the conductivity was increased, the power of non-conduction was, to some extent, obliterated, to what extent he did not know. What was the difference in the conductivity of the loose silicate cotton of one specimen, and of the hard material which he understood was the same stuff, or something like it, cemented over? He would expect to find, if his views were correct, that the conductivity was higher in the harder substance than in the looser form.

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Mr. BIRD said he thought Mr. Ross was under a mistake when he said that he (Mr. Bird) did not in the experiments do justice to silicate cotton. He tied it on; but if it was to be packed on and have an iron tube round it, that would increase its conductivity and would increase the cost. He thought, if anything, he had done more than justice to silicate cotton. Mr. Ross and other gentlemen were quite at liberty to come and co-operate in the experiments, and he believed he gave Mr. Ross an invitation. He (Mr. Bird) was acting for one of the materials, but that was not the cause, but the effect of his experiment, and he had acted only since the reading of his paper. He estimated the possible loss from an uncovered vertical boiler at 15 per cent., 9 per cent. radiation and 6 from other causes. In answer to Professor Lebour he said that *prima facie* there was every reason to suppose that the loose cotton would be better than the cemented cotton as a non-conductor. The conductivity fell from 67 per cent. in the silicate to about 40 per cent. in the cement. If Mr. Lebour examined the cemented composition he would find that its pores were multiplied more than in the silicate cotton.

Mr. J. A. G. ROSS said with regard to some remarks as to the desirability of using very thick coverings of non-conducting material, that he had the result of some experiments tried at an Exhibition in London which showed very conclusively that a thin coating would char in a short time. One inch thickness of silicate cotton, covering a temperature of 500 degrees, was sufficient to char a piece of soft wood as an outside covering in 1¾ hours; when 2 inches thick, two hours over the same temperature did not char the wood so much; when 3 inches thick, 2 hours in the stove at the same temperature caused but a very slight discoloration of the wood; with 4 inches thickness, 4 hours in the stove, at a temperature of 700 degrees, caused neither charring nor discoloration; and with 5 inches thickness and 700 degrees, it took 12 hours in the stove to obtain the same result. Although there might not be a corresponding advantage from an inch of thickness, yet it was an advantage in some cases where there was so much heat passing as would set fire to anything. He knew a case where a boiler set fire to wood cleading in a vessel when near the Orkney Islands; the ship was nearly lost, and perhaps another inch of thickness would have prevented the disaster and saved additional expenses.

Mr. BIRD said that in his experiments he only had a temperature of between 200 and 250 to cover. It was quite usual on a steam pipe to double the thickness of a covering, and, no matter what was used, doubling the quantity increased the cost. In no case in his experiments

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did the increase of efficiency from doubling the thickness come up to 20 per cent., the average was only 16 per cent. That was only what was expected, considering the laws of heat. If the first inch stopped 70 per cent. of heat then another inch would barely stop the remaining 30 per cent. He thought a material had no right to be called a non-conducting material if it had to be made thicker than 1½ inches.

The PRESIDENT said that, as somewhat supporting the Secretary's theory of utilizing air as a covering for steam pipes, he might state that at his pit the boilers had a covering of fire-bricks or quarls, supported on iron rails, which was found efficient in preventing the radiation of heat from the boilers, and, at the same time, the boilers could be got at without any difficulty.

The meeting then concluded.

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PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 14TH, 1883, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting. The minutes of the Council meetings held on March 31st and April 14th were also read, including the Reports of the Committees appointed respectively to deal with the Hutton Collection of Fossils, and to consider the circumstances in connection with the recent explosion of an Air-receiver at Ryhope Colliery.

On the motion of the PRESIDENT the minutes and reports were confirmed.

The following gentlemen were elected, having been previously nominated:—

ASSOCIATE MEMBERS—

Mr. HENRY ARMSTRONG, M.E., St. Hilda Colliery, South Shields.

Mr. INGHAM H. WEBSTER, Rope Manufacturer, Morton House, Fence Houses.

Mr. PETER SINCLAIR HAGGIE, Gateshead-on-Tyne.

STUDENTS—

Mr. GEORGE HURST, Lauder Grange, Corbridge on-Tyne.

Mr. DOUGLAS HAGGIE, Harton Colliery, South Shields.

Mr. C. H. STEAVENSON, Durham.

The following were nominated for election at the next meeting:—

ASSOCIATES—

Mr. WILLIAM HILL, Colliery Agent, Carterthorne Colliery Offices, Witton-le-Wear.

Mr. JOHN R. WILSON, Swaithe, near Barnsley.

Mr. W. J. PHILLIPS, Ansley Hall Colliery, Atherstone.

STUDENTS—

Mr. RALPH RICHARDSON, Field House, West Rainton, Fence Houses.

Mr. ARTHUR D. MILTON, Sherburn House, Durham.

Mr. ROBERT R. LISHMAN, 33, Claypath, Durham.

Mr. R. S. ANDERSON, Elswick Colliery, Newcastle-on-Tyne.

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The following notes relative to a paper by Mr. WIGHAM RICHARDSON "On the Strength of Wrought Iron in Compression" which appeared in Vol. XXX. of the Transactions, were read:—

IT will be within the recollection of many of the members of the Institute, that Mr. Wigham Richardson read a paper on April 7th, 1880, which was discussed at the time it was read, and in which that gentleman seemed to infer that the inference from Fairbairn's experiments was that the strength of pillars in compression increased as the sectional area increased, but at a very much greater rate. When the matter was discussed on December 4th, 1880, Mr. Richardson stated that he intended to make some experiments on this subject, and he desires now to make known to the members, that he intrusted them to be carried out by Mr. David Kirkaldy, and that the first twelve gave the following results:—

EXPERIMENTS ON THE STRENGTH IN COMPRESSION OF 12 PIECES OF TUDHOE CROWN IRON BY DAVID KIRKALDY.

Diameter. Inches.	Length. Inches.	Stress Elastic per Sq. Inch. Mean Tons.
1½	2	14·895
1	2	13·958
¾	1½	14·047
½	½	13·988

As therefore these results were so unmistakeably in direct opposition to the theory which was set up in his paper, he thinks it only right to publish them in the Proceedings, and, with the information thus afforded, give the members a further opportunity of discussing the undoubted discrepancies in the formulæ given by Fairbairn and others on this subject. Mr. Richardson had sent up the actual specimens tested, and they could be examined by members at any time.

The following paper by Mr. W. S. GRESLEY, "On Two Systems of Working the Main Coal at Moira, in Leicestershire," was then read:—

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TWO SYSTEMS OF WORKING THE MAIN COAL AT MOIRA, IN LEICESTERSHIRE.

By W. S. GRESLEY.

The following observations may be considered as supplementary to the paper contributed to this Institute by Mr. George Fowler, at the Birmingham meeting, in 1861, and published in the Transactions, Vol. X., page 161. They aim at giving a description of the further development of the methods of working the seam of coal therein described, viz., the "Main" coal of the Moira, or western division of the Leicestershire and South Derbyshire coal-field.

This paper is intended to be more of a descriptive than an argumentative one, though any questions put will of course be replied to.

DESCRIPTION OF THE MAIN COAL.

This is the principal bed of coal in the district. See Map and Sections, Plate XIV. Its thickness varies between 10 feet and 14 feet. It is, taking it as a whole, a hard coal—some bands being exceedingly hard and tenacious; others are soft, commonly called dice. The enlarged Section, Fig. 3, shows the different beds or divisions of which the coal seam is made up, their thickness, and leading characteristics. It is a valuable house coal; the inferior parts make a useful manufacturing fuel; the upper divisions, when burnt, leave a white ash, the lower ones a red ash. The specific gravity of the over coal is about 10 per cent. higher than that of the nether coal.

Although containing no parting in the southern portion of the coal-field, the seam is, in the northern district, divided into two distinct beds; a dirt-bed setting in, in the middle of the seam, about the centre of the basin, which thickens out in a northerly direction until near the outcrop; the two beds are separated by no less than 60 feet of measures. It is also somewhat remarkable that, whereas in the south the upper half of the seam is the best in quality, the reverse is the case in the northern end, so

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that about the centre of the coal-field both divisions, or in other words, the whole seam, is, taking it altogether, of much the same quality throughout. It is in this locality that the systems to be described have been adopted. See X on Map, Fig. 1, Plate XIV. The main coal is met with at a depth of about 350 yards where deepest, which is in the neighbourhood of Moira. Section, Fig. 2. At this point it was worked in much the same manner, as will be explained under No. 1 System, the nether coal being left. See Mr. Fowler's paper before referred to. The depth at which No. 2 System is now being carried on is about 290 yards. The coal lies almost flat, but it is much broken up by faults (about as many downthrows as upthrows), varying between a foot or so up to 14 yards, running nearly east and west. The cleat of the coal in one portion of the seam is no criterion as to the direction of it in the other; for instance, the over coal may be much subject to slips (smooth slippery joints running in several directions), when the nether coal is often entirely free from them. The coal contains a good deal of pyrites or stone, which occurs in small patches, strings, and crystals, and as thin plates in the cleat or joints.

Naturally the seam is very liable to spontaneous combustion, even small heaps of slack lying upon the gate roads, and the slack within the brattices, shown in Plate XVIII, have been known to heat and take fire.

The roof is naturally a bad one. The big Rider coal is a moderately hard seam, and burns to a white ash; it is never worked. Occasionally it is found lying immediately upon the main seam, when an aggregate thickness of something like 18 feet of solid coal is the result. Again, it is here and there altogether absent, and the roof, instead of being composed of clay, is replaced by bind and occasionally by sandstone.

No workings of any description have been carried on either above or below the main seam in the locality to which the following remarks refer.

To those who are acquainted with the working of thick seams, an inspection of the plans, sections, and tabular statement of results in working given, will at once show the great contrast which there is, and the improvement No. 2 System must obviously be over No. 1 System; but for those who are not so well up in the subject, each system will be described somewhat in detail, supplemented with a few observations in support of, or prejudicial to, the one or the other.

The remark made some time ago by Professor W. W. Smyth, in reference to the wasteful system of getting the ten-yard seam of South Staffordshire may here be quoted as certainly applicable to the Moira district. He says:—"The acknowledged requisite for the most advan-

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tageous method of working, viz., the combination of the cheapest mode of extracting the greatest possible quantity of mineral, with the safety and comfort of the men, has in this district been greatly modified by the circumstances of position, and an adherence to long established customs. In a few rare instances only have any attempts been made to substitute a new system for the old routine."

NO. 1 SYSTEM.

This was, up to within the last few years, the only method of working practised. The one object in view being to extract the hardest or so-called best divisions, which are chiefly confined to the upper half of the seam, led to the adoption of this system to the almost entire exclusion of any other. Plates XVII. and XIX. show the usual manner in which the underground workings were carried on, viz., a modification of the Long-wall method on the Gob-road system, *i.e.*, commencing to work out the coal at or near the shaft, pillar, or main-road pillar side, and extending outwards towards the boundary. The mode of operating was as follows:—The face of workings, which averaged about 6 feet 3 inches in height, was generally started out of the side of an opening off head (the headings being driven partly in the over and partly in the nether coal, say 6 feet high by 8 feet wide, thus avoiding timber for roof). The holing was 3 feet 3 inches in depth, the bottoms (grounds and scalps) were first benched up with hammer and wedge, and stacked up on one side out of the way for loading. The next operation was to draw the sprags and to break down the remaining coal, which was done by a set of men called drivers, 12 or 14 in number. They commenced work at 4 a.m., following the holers, who began several hours sooner, placed themselves along the wall at intervals of about 6 feet, and went through the laborious work of forcing off the coals by means of hammers and wedges up to the back of the holing, though very frequently much of the holing was left on. The coals were seldom if ever brought down in a mass, but were much broken up, and of course much slack was produced. The driving was followed up by the filling; four tubs were filled simultaneously, two in each end or bank. Preceded by the fillers a man was employed called a "turner-out," who overhauled the broken down coals and placed them conveniently for loading up; two tubs were filled at a time. Scarcely any small was sent out, say one tub in every ten was slack, work slack it is termed, as distinguished from heading slack or slack produced by cutting coal in driving gate-roads. This was loaded separately and paid for at a lower price than for the coal.

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The fourth set of men, called "nightsmen," appeared upon the scene towards the close of the day's work. Their work consisted in pulling up the rails, clearing out the floor by throwing all the small into the goaf, setting holing sprags, drawing the back wood, setting a front rank of props, ripping the gate-road, building brattices, wax walls, etc. Figs. 1, 2, and 3, Plate XVIII. Owing to the great length of the stalls, often 100 yards, the push made towards the end of the shift to get the work out was anything but conducive to economy, an alarming proportion of large being gobbed in order to get it out of the way, to make room for the succeeding shift.

The direction of the gate-roads depended upon that which the ends or cuttings took, and these were of course regulated by the length of face required, by faults or other boundaries, the average distance apart would be from 80 to 100 yards. They were made and maintained as follows:— On leaving the shaft or other solid pillar of coal, carefully built stacks or brattices of cordwood about 3 feet in width were put up on either side of the road from floor to roof, leaving a clear width between of from 8 to 9 feet. Plan and cross Section, Figs. 1 and 2, Plate XVIII. Beyond these at a distance of about 3 feet were formed walls constructed of tough, well-tempered clay called wax, about 10 inches thick, well beaten, and carefully filled in up to the solid uncracked coal. This wax wall was intended to prevent fire stinks from breaking out along the rib side, which purpose it only partially or in some instances fulfilled. Wax walls or not, a fire-stink very frequently, sooner or later, made its appearance at the opening off, often giving much trouble and lasting for many years. It was the practice to fill in the spaces between the brattices and the wax walls with slack. As the faces advanced these arrangements were carried forward, always being kept up to within a few yards of the working face. The roof was ripped about 3 feet 6 inches, and generally required barring. Fig. 3 shows the condition of a gate-road after full subsidence had taken place. No packs were built in the stalls excepting at the fast ends; these were for keeping open a short air-way along the curving from the face to the shallow pits (curry pits), which were sunk down into the nether coal, and gave access to the return air-course formed beneath the goaf. See dotted lines, Plate XVII., and Fig. 1, Plate XVIII. These curry pits were put down at say every 20 yards, and short bolt-holes, or thirls, were driven from them into the air-way, as each new pit and thirl was made the one to rear was stopped off. The return air-ways were only about 3 feet square, and frequently extended many hundred yards before joining the

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main air-way, if one of large dimensions were employed, which was not at one time the rule. The quantity of ventilation capable of being passed along such windings, as the air-courses were termed, was very limited. They got out of repair, and were not too often travelled.

As the workings increased in distance from home they naturally became very close and even hot, in fact anything but comfortable to work or even to travel in. Gob fires, and the breaking in of water here and there, also helped to condemn the system. Naked lights were used; gas was seldom seen. For supporting the roof ordinary puncheons were used, with clogs, or lids, about 30 inches long placed on the top of them. Cast iron props were tried, but were abandoned being considered unsuitable. The works were carried on under the Butty system; there were about thirteen butties in each stall. Holing was paid for by the stint; each holer could get six stints per shift, or 12 yards along the face, 3 feet 3 inches under. The drivers got say five sets for a day's work, a set consisting of $1\frac{1}{2}$ yards on the face by 3 feet forward. Filling was done at per ton. The nightsmen were made up of one butty, two slack throwers, and one repairer. All work performed in the stalls was paid for by the butties, or contractors, at fixed prices regulated by the manager and viewer. The yield per acre was about 4,750 tons. See tabular statement, page 190.

In a few instances the above method of working was practiced with this difference, that instead of working outwards by gob-roads, working home in the solid was substituted, the goaf being all left behind. This plan was in some ways an improvement, and the charter or contract price for getting was about 2d. per ton less, but the extra cost incurred in driving the gate-roads had to be added, so that on the whole not very much was gained by the change, though the greater convenience obtained with respect to ventilation, less chance of spontaneous fires, comparative freedom from water, gas, etc., less timber required, more easily maintained roads, a knowledge of the size and direction of faults to be crossed, and so forth, was clearly a step in the right direction.

NO. 2 SYSTEM.

This was commenced about four years ago. The leading features are, to work out a much larger proportion of the seam, to do away with the costly process of wedging down the bulk of the coal, to produce the coal in large masses, thus obtaining it in a better condition for stacking or carriage, and to materially reduce the cost of extraction. This method is known as working back or working home. The gate-roads, air-courses, and opening-off headings, are first driven, thus proving any faults, old

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workings, etc. The stall faces are then started. All brattices, wax-walling, carvings, curry pits, long windings, gob-fires, ripping of gate-roads, etc., incidental to No. 1 System, are thus rendered unnecessary.

The gate-roads are formed in the nether coal, leaving about 5 feet of coal for a roof, and 1 foot under-foot. They are driven about 50 yards apart. See Plate XX.

These roads are driven on an entirely new method, which enables a greater proportion of round coal to be obtained than has hitherto been produced by heading in the district. In the first place, what may be called a pioneer heading (3 feet 3 inches by 3 feet 3 inches) is driven forward on one side, or in one corner, level with the floor of the intended way, to a distance of say 5 yards. Secondly, the coal is holed for about 6 feet along the side of the little head 6 feet deep. Thirdly, the coal is cut or nicked on that side which is over the little head to a depth of about 6 feet, this is termed a shoulder-cutting. Lastly, a shot is put in, say a foot or 18 inches from the roof, and the coals fall in large blocks. The finished size of such a gate-road is 9 feet wide by 8 feet high. The pioneer or little head is always kept about 3 yards in advance of the back of the large heading, For each yard advance, about 7 tons 7 cwts. of coal and small will be produced, about 73 per cent. of which is large coal. See Table page 190. The weekly advance will be about 17 yards = 125 tons.

Four men can work at the back simultaneously, viz.:—One to drive the pioneer heading, one to hole, one to shoulder-cut and drill the shot hole, and one to load up the coal.

The ventilation is maintained by brattice cloth 8 feet wide. All the over coal being left, no timber is required to carry the roof.

Air-ways, if formed for ventilation only, are made about 4 feet square, when of no great length, and always in the bottom coal.

Turning to Plate XXII., it will be seen that the holing is made to a depth of not less than 6 feet, and when the sprags are taken out the coal generally falls up to about 8 feet in thickness from floor. A shot has occasionally to be put in to bring the coal away, but there is a good shed at top. When three or four webs or falls have been worked off, packs about 9 feet in width are built, having spaces or bays between them 18 feet wide, excepting that opposite the gate-road, which is only 12 feet in width. Plate XXI. These packs are carried forward in parallel lines, being added to as each web is removed. Plates XX. and XXI.

The over coal, or gob coal as it is commonly called, is systematically taken down in the wastes between the packs up to the second rank of props. Coal on the top of the packs is wrought in the following way, see Plates XXI. and

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XXIII. :—It is worked out backwards or away from the face, commencing at a bolt-hole or thirl, which is first cut through in the gob coal a yard or two to the rear of the front of the pack, and going in about 10 yards, generally leaving about two yards of coal against the last bolt-hole. At the back of the wastes, as soon as all available coal has been got out, the timber is drawn, and the roof allowed to fall in, and should the place show signs of heating, it is forthwith stacked out, *i.e.*, a cross pack, one built right across a waste between two ordinary packs, is put in, and when necessary, the front of it is thickly smeared with well tempered clay. The process is called waxing; but with regular working, and a moderately good roof, this is seldom required. It is customary to put in a cross pack about every 20 yards. The packs are built chiefly of stone coal got in the waste. The only drawback to this system of working seems to be the large percentage of small produced, caused by breaking up the nether coal for loading into tubs. It will often get (fall over from the face) in immense solid blocks, from 6 to 10 tons in weight, but will not stand much handling and knocking about.

The mode of ventilating is very simple and efficient. Besides the main current of air coursing along the faces, a second one flows through the wastes, passing from one to another through the bolt-holes in the upper coal. Plates XXI. and XXIII. As the result of changing the system, whereby the narrow windings (air-ways under the goaves) have been done away with, the water-gauge is now ·6 inches as against ·95 inches under the old system. See tabular statement, page 190. Gas is seldom seen, and it is usual to meet with it only in the broken down places in the backs of wastes, and against rib-sides at the goaf edges at the rise end of a range of stall faces.

The several operations performed in getting the coal in the manner just described, are carried out thus:—The holing is done by a shift of men who work from 2 a.m. till say 10 a.m.; each man holes at least one stint, that is, 7 feet in length and 6 feet under = 42 square feet. Butties then draw the sprags and bring down the coal; they also get the gob-coal, and assist in building packs and setting timber, stacking out, etc. At 7 a.m. the fillers come in and work till 5 p.m.; one of the butties always accompanies the turn, loading out the coals. The work is paid for in the same way as under the old system. It is generally found that the coal gets best, produces the greatest quantity of large, when it is worked about three on face to one on end, known as horn coal.

The reason No. 2 System was adopted was chiefly on account of the very high cost of getting and the large consumption of timber attending

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the old method. The greater uniformity in thickness and quality of the nether as compared with the over coal also favoured the change, which, although entailing the loss of a small portion of the over coal necessarily left in the wastes, amounting to say 10 per cent. of that particular bed, is probably fully compensated for in the extra quantity of large coal obtained from the nether seam due to the new system of holing and getting. The grounds also which are now obtained whole and in blocks of almost unmanageable size, were formerly knocked to pieces by the wedging system. Thus it will be noticed that the working of the entire thickness of the nether coal is a clear gain. Compare Plates XIX. and XXII.

As regards accidents due to the change of system, so far there has been nothing serious whatever, and it is considered that the new method is quite as free from danger as the old one. Gas when seen is now much further away from the men than before. No change in the lighting has been introduced, naked lights being the rule. Shot firing is only practiced when the coals will not easily fall, and when it is required to break up blocks too large to be dealt with, with hammer and wedge. The whole length of face only being turned over or gone through once a week allows the roof to settle and weigh upon the timber to a considerable extent, and it is thought that the driving of more gate-roads, say about double the number now formed, would materially benefit the system; it would at any rate enable the output to be largely increased if required without extending the pit room; in fact were it practicable, four times the number of hands could be put into the same length of face, or the output increased in like proportion. It must not be supposed that the so-called slack sent out of the works is really quite small stuff, for about 66 per cent. of it consists of cobbles and nuts, the remainder being dust. About 10 per cent. of the gross output is slack. Were it practicable a considerable extra quantity of slack would be sent out without seriously affecting the safety of the stalls in regard to fire stinks, it is necessary, however, to have something to gob with in order to prevent them.

The advantages derived from the alteration of the systems of working may be summed up as follows:—

1.—Less waste in working, or nearly double the yield for the same area worked.

2.—Less liability to accidents, particularly from fire-damp.

3.—Almost entire immunity from spontaneous combustion.

4.—Reduced cost of getting, including timbering.

5.—Less pit room required, or in other words, quadruple the output for the same length of face.

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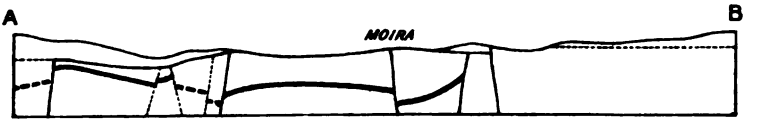
To illustrate Mr. W.S. Gresley's paper "On Two Systems of working the Main Coal at Moira, Leicestershire."

FIG. 2.
SECTION ON LINE A.B.



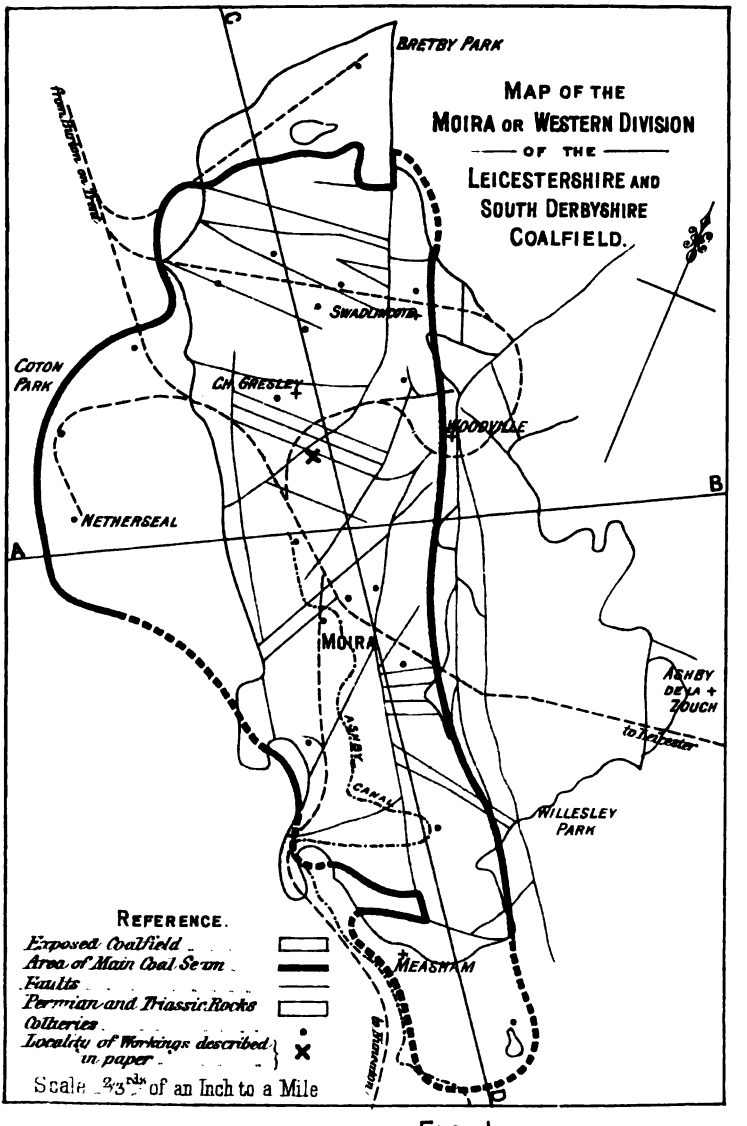


FIG. 3.
SECTION ON LINE C.D.

FIG. 1.

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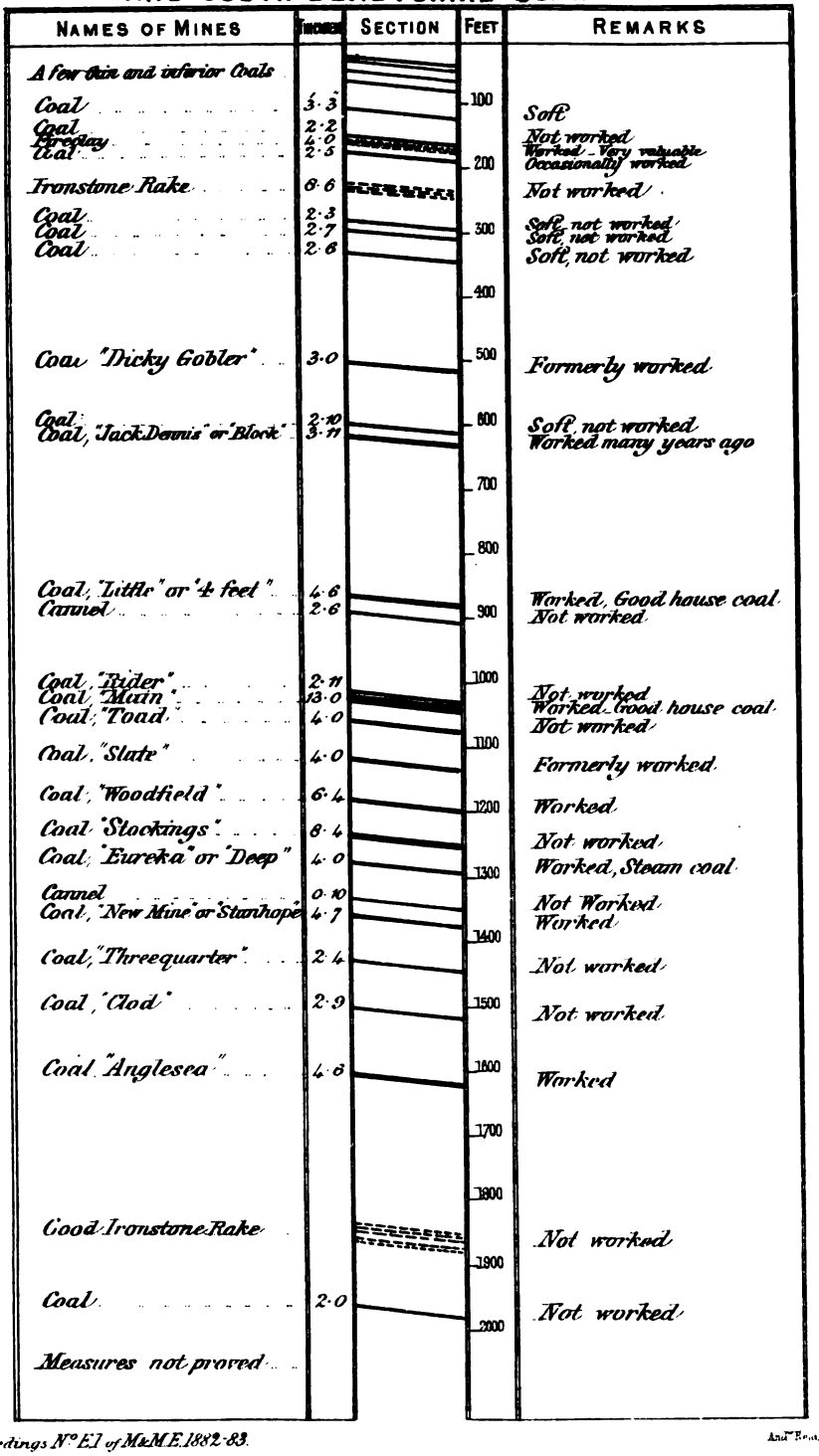
General Section of Mines of the Leicestershire and South Derbyshire Coalfield.



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Gresley's paper "On Two Systems of working the
Coal at Moira, Leicestershire."

ION OF MINES OF THE LEICESTERSHIRE
OUTH DERBYSHIRE COALFIELD.

ES	THICKNESS	SECTION	FEET	REMARKS
r Coals				
	3·3		100	Soft
	2·2			Not worked
	4·0			Worked – Very valuable
	2·5		200	Occasionally worked
	8·6			Not worked
	2·3			Soft, not worked
	2·7		300	Soft, not worked
	2·6			Soft, not worked
			400	
obler"	3·0		500	Formerly worked
s" or "Block"	2·10		600	Soft, not worked
	3·11			Worked many years ago
			700	
			800	
r "4 feet"	4·6			Worked, Good house coal
	2·6		900	Not worked
	2·11		1000	Not worked
	13·0			Worked, Good house coal
d"	4·0			Not worked
	4·0		1100	Formerly worked
dfield"	6·4		1200	Worked
ckings"	8·4			Not worked
reka" or "Deep"	4·0		1300	Worked, Steam coal
	0·10			Not Worked
w Mine" or "Stanhope"	4·7		1400	Worked
hreequarter"	2·4			Not worked
Clod"	2·9		1500	Not worked
"Anglesea"	4·6		1600	Worked
			1700	
			1800	
nod Ironston			1900	
			2000	

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To illustrate Mr. W.S. Gresley's paper "On Two Systems of working the Main Coal at Moira, Leicestershire."

SECTION OF THE MOIRA MAIN COAL WHERE MARKED X ON MAP.

Local Names of Beds	Characteristics	Section	Thickness Feet Ins.	
Bind with Ironstone			50·0	
Big Rider Coal	Moderately hard		2·11	
Black and Grey Stone	Tough		1·6	
Little Rider Coal	Soft		0·8	
Clot	Shale and Clay		1·0	
Roof Coal	Soft		1·2	
Stone Coal	Very hard spirey white ash coal		1·0	Numerous slips smooth inclined partings or 'backs' in these divisions
Over or Main Coal	Hard white ash (second quality)		2·10	
Holing dirt	Soft coaly bed		0·6	
Scalps	Dice, Smiths' coal		1·0	
Grounds	Hard bright (best)		1·0	
Nether Coal	Hard and Soft mixed a red ash coal (third quality)		3·9	Falls in one solid mass when sprags are drawn. Free from 'Slips'
Brown Spires	Very hard dull seam		0·6	
Dice	Soft		1·3	
Dun Dick	Inferior Coal		1·0	
Clot	Fireclay		0·9	
Coal			0·9	
Sandstone	Sharp		24·0	

Scale _ 4 feet to an inch.

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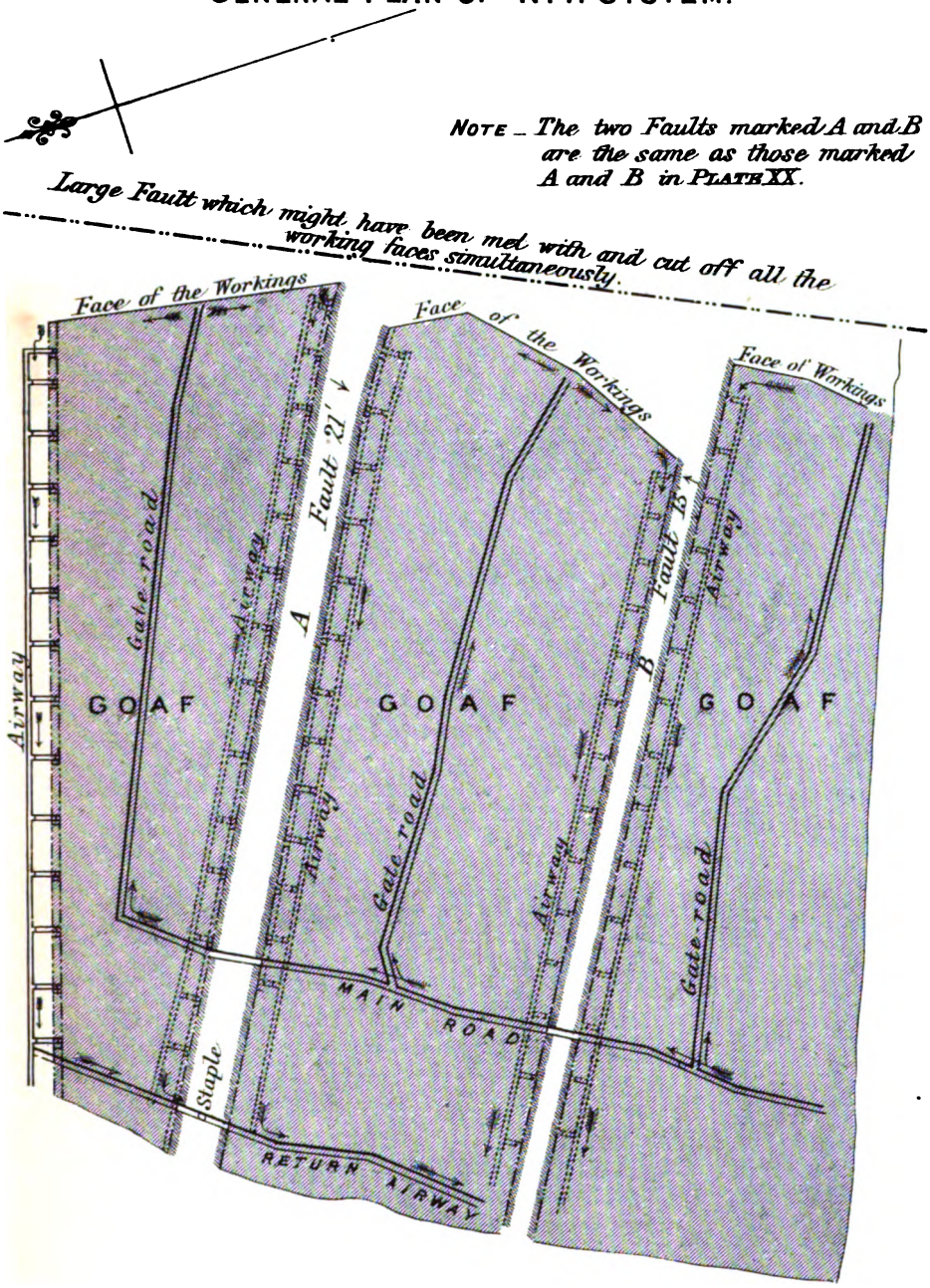
To illustrate Mr. W. S. Gresley's paper "On Two Systems of working the Main Coal at Moira, Leicestershire."

General Plan of - No. 1. System.



Scale _ 3 Chains to an Inch

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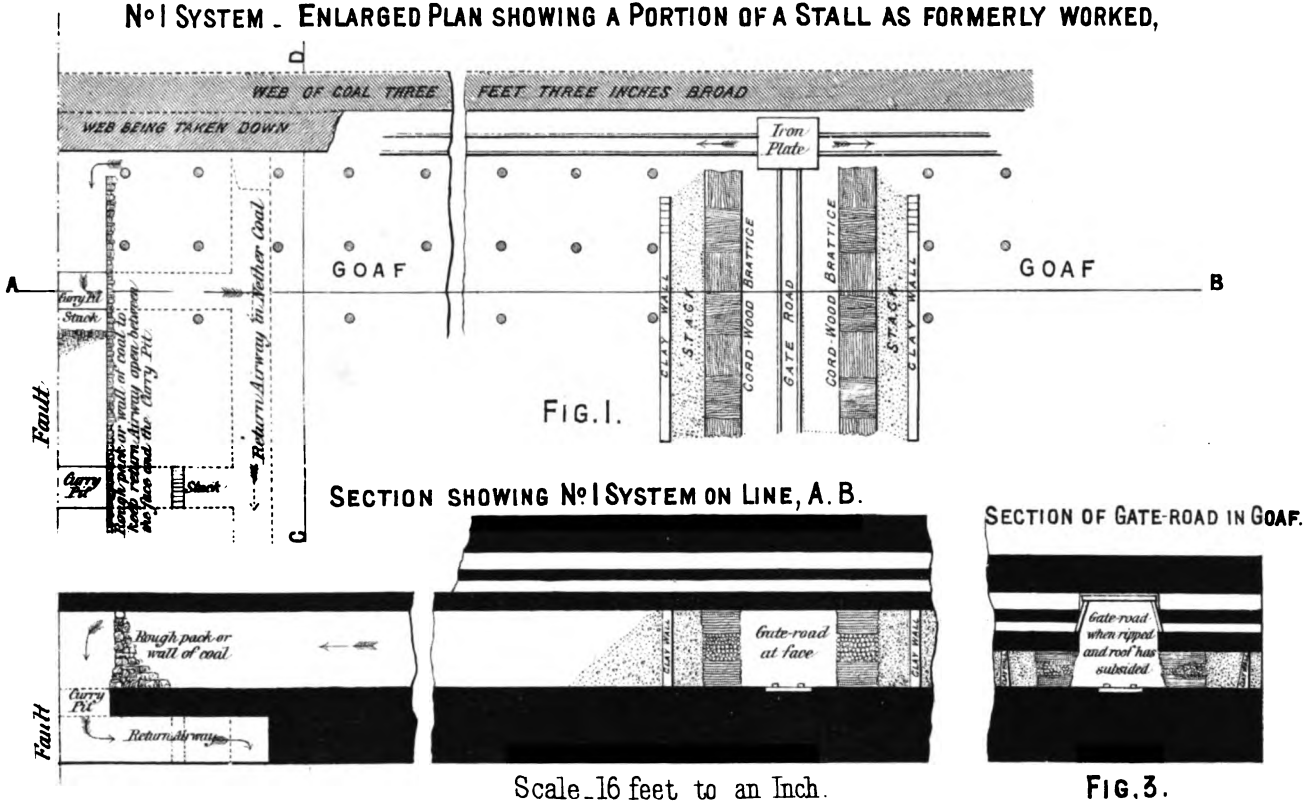

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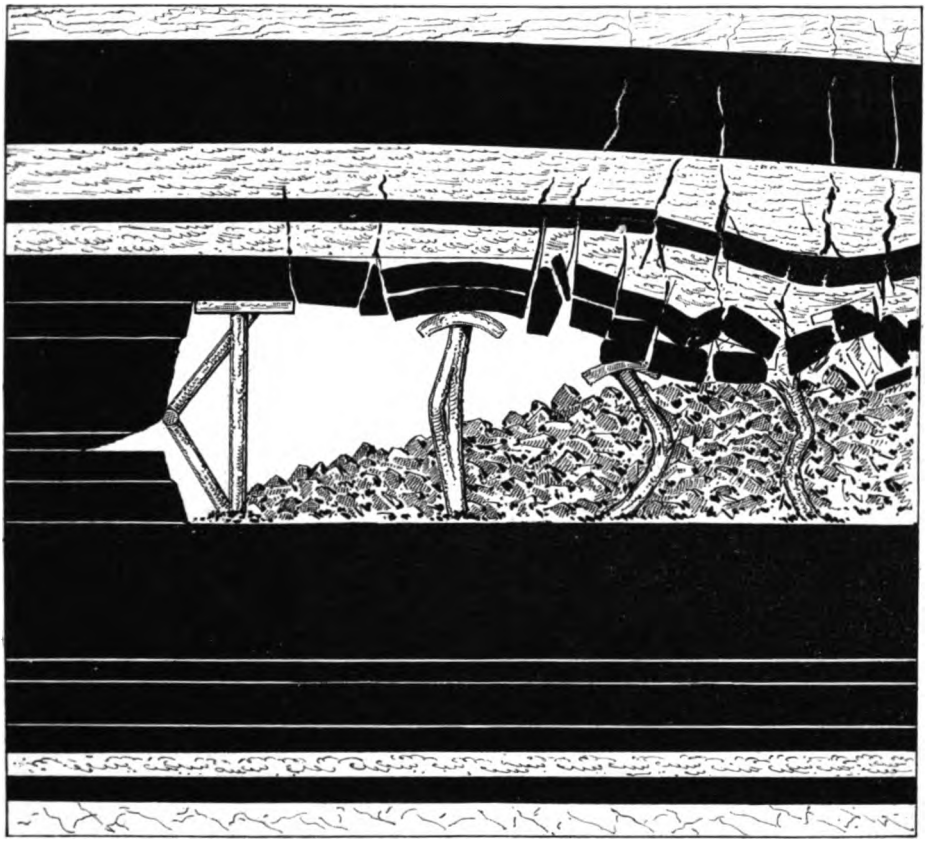
To illustrate Mr. W.S. Gresley's paper "On Two Systems of working the Main Coal at Moira, Leicestershire."

No. 1, System.—Section of Stall on Line C.D.

Plate XVIII.



Scale.—5 Feet to an Inch.

And. Reid Newcastle

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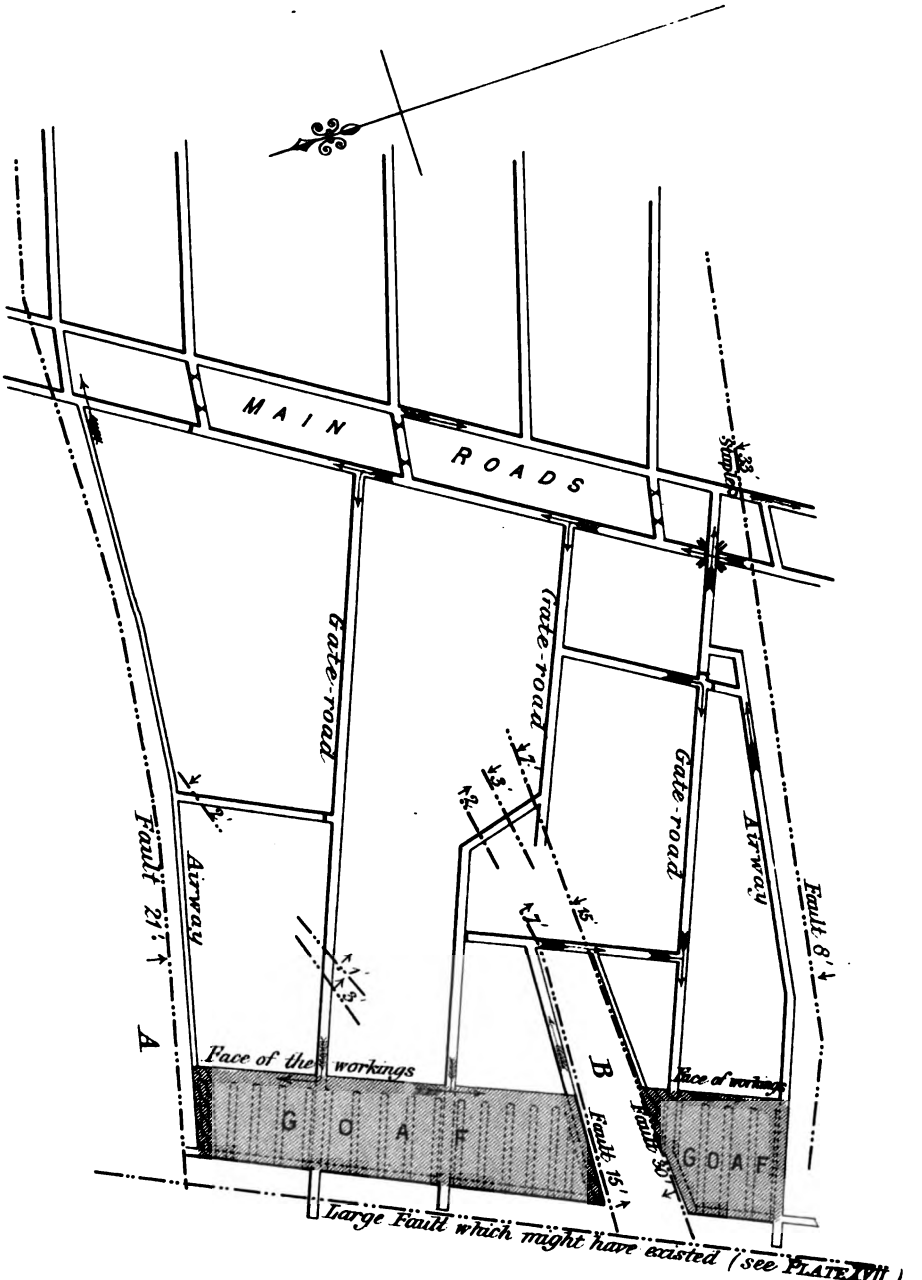
To illustrate M.r W.S. Gresley's paper "On Two Systems of working the Main Coal at Moira, Leicestershire."

General Plan of No 2. System.



Scale 3 Chains to an Inch

And.w Reid Newcastle.

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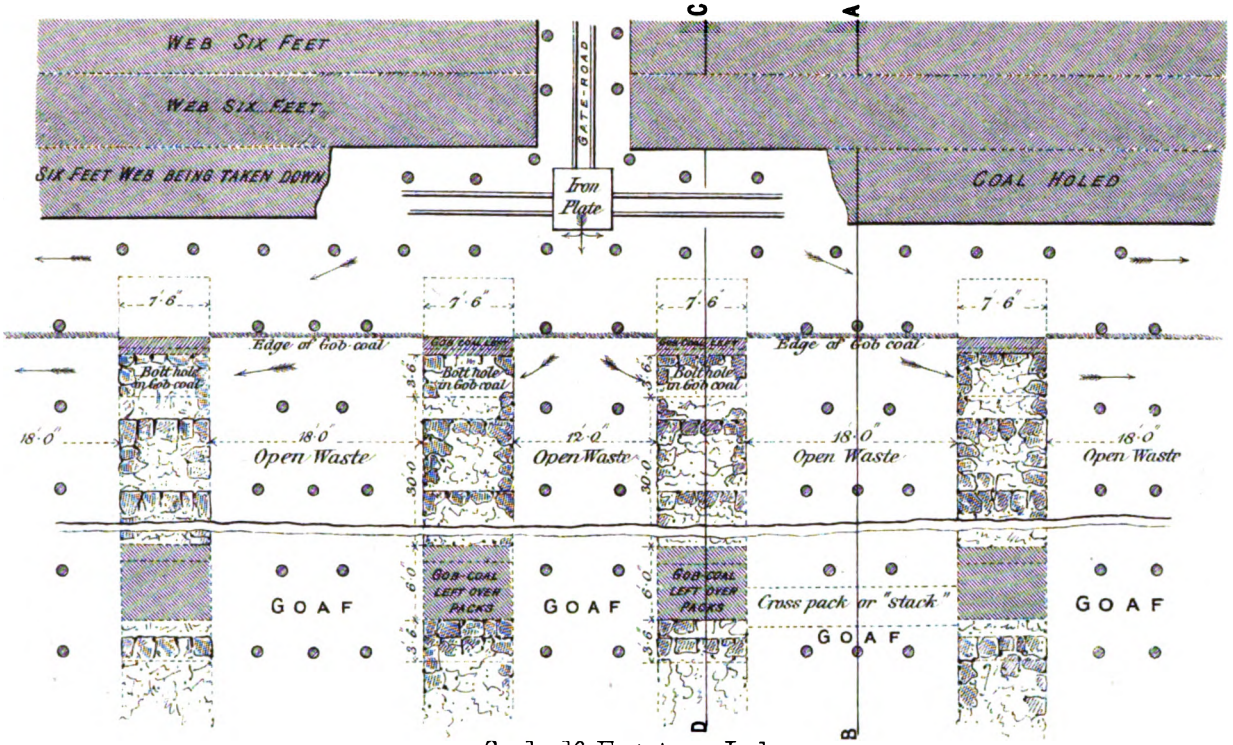
To illustrate Mr W.S. Gresley's paper "On Two Systems of working the Main Coal at Moira, Leicestershire."

No 2, System – Enlarged Plan showing Portion of a Stall as now worked.



Scale 16 Feet to an Inch.

And.r Reid, Newcastle

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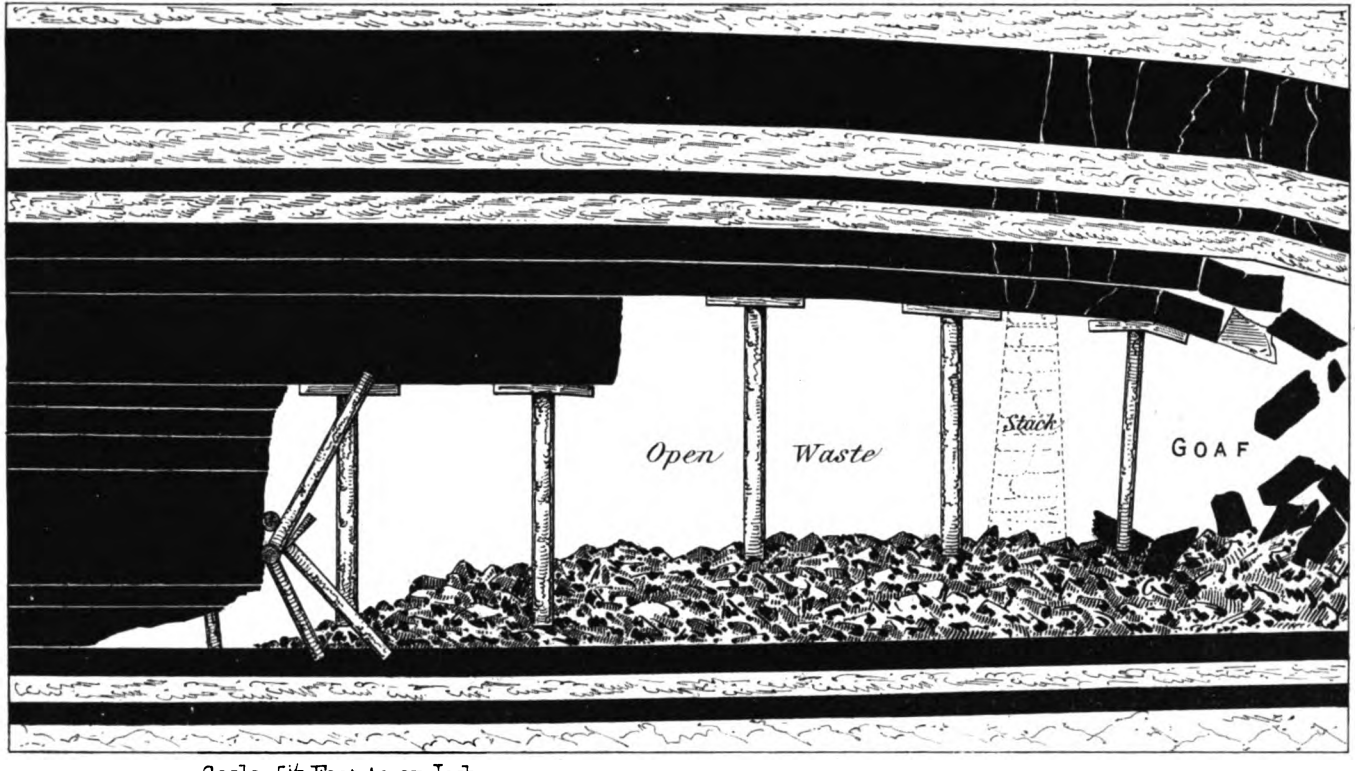
No. 2, System – Section of Stall on Line A. B. *Plate XXI.*



Scale – 5⅓ Feet to an Inch.

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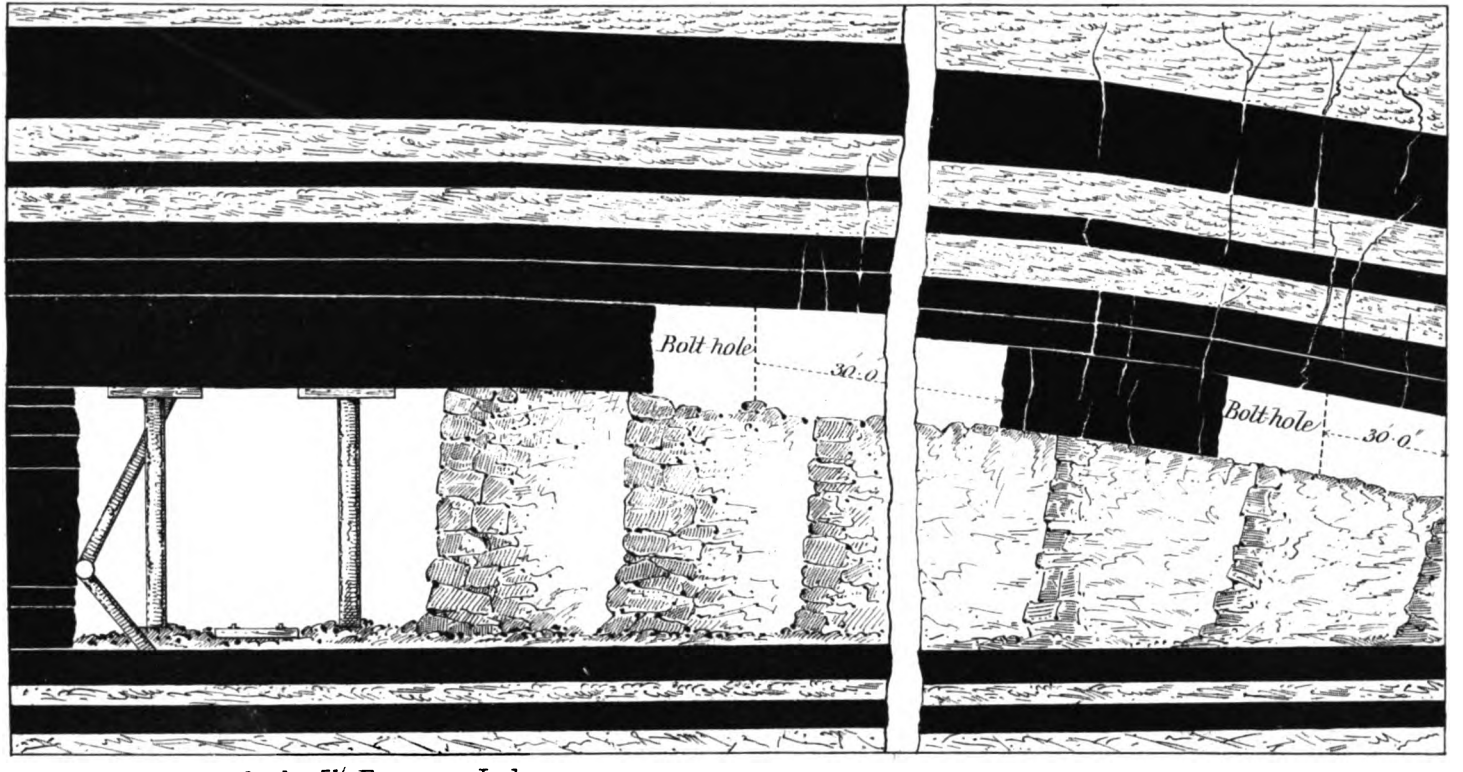
To illustrate Mr. W. S. Gresley's paper "On Two Systems of working the Main Coal at Moira, Leicestershire."

No 2, System – Section of Stall on Line C.D. *Plate XXI.*



Scale – 5⅓ Feet to an Inch.

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6.—Less men per stall to the extent of 44 per cent., or an increased weight of coal got per man per day.

7.—A far better roof to work under.

8.—Ability to work the lower half of the seam where the upper portion is inferior.

9.—Having the coal-field proved before commencing to work back, thereby enabling faults to be crossed and dealt with in the most advantageous way.

10.—The abolition of wedging down the coals; a very laborious, wasteful, and expensive operation.

11.—Increased facilities as regards ventilation of the working places and gate-roads.

12.—Greater comfort afforded to both men and horses whilst at work, due to a purer and cooler atmosphere, more even roads, more space to work in, and getting more work out of the men per shift.

In conclusion, the revolution in the system of working this seam of coal has resulted in two main features:—

1.—Greatly increased economy in working expenses combined with much less waste of coal in the pit.

2.—A lowering of the average selling price per ton in consequence of two things:—

a.—A smaller proportion of the best quality due to the working of about one-half the area for the same output.

b.—Getting the lower portion of the seam, which is comparatively soft, and for which something like two shillings per ton is obtained less than for the upper part of the seam. So that although profits may be no greater than formerly, they will continue under similar circumstances to be made over double the time that they otherwise would, because the seam is only being exhausted at one-half the former rate.

The author hereby acknowledges his thanks to Mr. G. Buxton, who has assisted in preparing this paper, and under whose supervision the new system of working described has been so successfully carried out.

The PRESIDENT said, that this was a very interesting and descriptive paper, about work they were not accustomed to here. He proposed a vote of thanks to the author, which was carried by acclamation.

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TABULAR STATEMENT SHOWING THE COMPARATIVE RESULTS OF TWO SYSTEMS OF WORKING THE MAIN COAL AT MOIRA. 1870 AND 1882.

Systems of Working.		No. 1. 1870.		No. 2. 1882.	
		Long-wall.	Gob-road.	Long-wall.	Working home.
Average Thickness of the whole Seam.*	Ft. In.	13 6		13 6	
Average Thickness of Seam Worked.	Ft. In.	6 3		10 0	
Theoretical Yield of whole Seam per Acre.	Tons.	20,520		20,520	
Actual Yield per Acre.	Tons.	4,750		9,350	
Waste in Working. Of the whole Seam.	PerCent.	77		60	
Waste in Working. Of the Thickness Worked.	PerCent.	50		38	
Pit-room required, or Length of Face per 100 tons.	Yds.	98		25	
Average Length of each Stall.	Yds.	100		50	
Output per Stall per Day.	Tons.	50		50	
No. of Men and Boys in a Stall.	No.	34		19	
Tons gotten per Man per Day.	Tons.	1·47		2·63	
Face moved forward during a Week.	Times	3		1	
Length of Turn.	Hrs.	12		10	
Cost of Holing, Getting, Filling, etc., at 1882 Prices.	s. d.	3 0		2 0	
Cost of Timbering.	d.	10		5	
Over-coal left.	Per Cent.	...		10	
Gate-Roads. Sectional Area.	Sq. Ft.	48		72	
Gate-Roads. Yield per Yard.	Tons.	5·1		7·4	
Ventilation. Total No. of Cubic Ft. per Minute.	Cu. Ft.	16,000		25,000	
Ventilation. Water-Gauge.	In.	·95		·60	

* Exclusive of the Big and Little Rider Coals, Holding-dirt, and the 9 inches of coal beneath the fire-clay floor. Plate XVI.

Mr. E. B. MARTEN read the following paper "On Explosions of Boilers and other vessels:"—

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ON EXPLOSIONS OF BOILERS AND OTHER VESSELS.

By E. B. MARTEN.

When the paper was read Mr. Marten exhibited about twenty cases of models of exploded boilers, each containing about twenty specimens. On the walls were hung numerous sketches and photographs of exploded boilers. Elastic models, historical models of various forms of boilers, the apparatus for experiments on the spheroidal condition of water, the decomposition of steam, and the hydro-electric machine were also placed for inspection.

The models have been the collection of more than twenty years, and, with the volumes of "Records of Boiler Explosions" and the photographs and sketches, form a very complete illustration of the subject.

Two objects have been kept in view. The first was to collect the best possible information as to the facts of every explosion, with a view to ascertain the cause, and the second was to make that information available to those interested, more especially to those having the actual care and working of boilers.

Reading being at best but a tedious process, it was found that a few sketches saved a volume of description. It was further found that a few models were worth a folio of sketches, and also much assisted in making the most effective and instructive pictures.

In order to extract as much instruction from the whole exhibit as possible in a limited time, some diagrams, given in Plates XXIV. to XXIX., have been specially prepared for this meeting to convey the points of greatest interest with the least possible description. A few words will explain the purpose of each figure on the diagrams.

First, as to the—

MODE OF ILLUSTRATION.

Fig. 1, Plate XXIV.,* is a copy of a very good drawing of a small exploded plain cylinder boiler at Manchester, 1848, which suggested that perspective sketches are better than engineering plans and sections for illustrating boiler explosions.

* Presented by Mr. William Smith to the Institution of Mechanical Engineers.

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Fig. 2, Plate XXIV.,* contains extracts from a pictorial catalogue of damaged parts of exploded boilers, made as a permanent record of an exhibition of such things at a meeting of continental engineers especially engaged in boiler inspection. They suggested an effective form of clear sketching.

Fig. 3, Plate XXIV.,† is a sketch of the locomotive "Neversink," which exploded at Reading, in America, in 1845, and is also an effective representation of what happened.

Fig. 4, Plate XXV., is a perspective view from the very complete drawings in the Institute Transactions, Vol. XI., page 27, of a boiler explosion at Seaton Burn, 1860, and shows how much information may be conveyed in one such view.

Very early in the course of collecting particulars of exploded boilers it was found wise to take sufficient details to make models of the boilers before and of the fragments after explosion. It was further found that the most effective sketch of the whole could be obtained by placing the model fragments around the model boiler in their relative position, and also in the best way to obtain a perspective view of the whole. Great assistance in this was given by the camera seen on the table, and represented in Fig. 5, Plate XXV. The drawing is made with French chalk on glass roughened with acid, or on perforated paper, the models being seen beyond, the eye-piece insuring steady continuance in the same view.

Fig. 6, Plate XXV., shows rather a complicated explosion, which was unravelled by means of placing the model fragments in their relative positions, and then studying the chain of circumstances that brought them in such unexpected positions. The only original damage to the boiler was a pocket over the fire, which was burnt through, and the reaction of the issuing contents turned the boiler end for end; but as this knocked off one end of the boiler the reaction of the contents from the open end sent the boiler in the opposite direction.

Fig. 7, Plate XXV., shows the lines of rupture in an air vessel, which burst under proof at 320 lbs. pressure, and being three-quarters of an inch thick and double riveted, caused much speculation as to the cause, because the fragments were so many and so widely scattered. As soon as the fragments were put together it became certain the rents commenced at the manhole, which was found to be a cast-iron frame, as usually made for ordinary boilers, without allowance for the extra strain for such high pressure.

* Copy presented to Institute.

† Report of Committee of Franklin Institute.

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It is always important to ascertain the position of the first rupture, but this cannot always be found by merely placing of the fragments without consideration of the appearance of the ruptured edges.

Fig. 8, Plate XXV., gives specimens of ruptures of plates or seams by mere pull, or by tearing upwards or downwards. Those shown at *a* and *d* may be first ruptures, but it is difficult to suppose that any of the others, *b*, *c*, *e*, *f*, could be, because the parts must have altered their shape and position from some previous rupture before such tears could take place.

Fig. 9, Plate XXV., gives a sample of an explosion which caused some puzzling, and some large pools were dragged expecting to find the front end blown to the front, but careful examination of the line of fracture showed that it had hinged on the good upper part of the ruptured seam, and had therefore been thrown backwards, and it was subsequently found in a very small deep pool to the rear neatly packed away out of sight just beneath the water.

AS TO THE CAUSES OF EXPLOSION.

It would be most tedious to go through each model, and therefore a few selected cases are given from which important lessons have been learnt in the past. As the printed "Records of Boiler Explosions since 1862" contain sketches of nearly all cases of interest with complete tabulated index, these will not be repeated here, a few special drawings for this paper being better suited to the purpose.

Fig. 10, Plate XXVI., represents the exploded boiler of the "Cricket," Thames steamer, which caused great discussion in 1847. The front end had the whole pressure with only one small stay at the back of the smoke-box, and was therefore of very weak shape, but the immediate cause of the explosion was the fastening of the safety-valve, as some asserted, by being purposely tied with string, but, as subsequently ascertained, by the deck of the vessel or the covering being put down over it without allowance for its rising.

Fig. 11, Plate XXVI., represents the coffee roaster, which burst at No. 1, St. Paul's Churchyard, and killed Mr. Dakin, the inventor. High-pressure superheated steam was introduced into a small annular space between the outer and inner cases. It worked well, and answered its purpose admirably on several occasions. On being set to work on the day of the explosion it failed immediately, a small piece being blown out. It was found that some water, condensed from the steam used before, had

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not been drained out, and the superheated steam suddenly converted this into steam of very high pressure, which could not find vent in the small pipes connected with the apparatus. The vessel was also weakened by rapid and unequal expansion.

Fig. 12, Plate XXVI., represents a most fatal explosion at Millfields in 1862, where twenty-nine people were killed, and which created a prejudice against this otherwise economical form of boiler for using the heat from puddling or mill furnaces, from the fact that they must stand among the men, and in case of rupture the water gets amongst the heated metal and increases the mischief. In this case the diameter was excessive, being 11 feet, and the gauge was found to be incorrect, so that it was 57 lbs. when showing only 30. All the sketches of similar furnace boilers will be found collected in the introduction to the second volume of "Records."

Fig. 13, Plate XXVI., shows the damage which resulted from a very small boiler which exploded, at Walsall, 1865, wrecked the house in which it took place, and flew over a wide market place and destroyed the upper story of a house on the other side. The manhole had been cut disproportionately large, leaving no plate between it and the end, so that the end had been blown out when the contents issued so violently as to cause the light boiler to re-act like a rocket.

Fig. 14, Plate XXVI., shows a boiler, Elsecar, 1868, in good condition, out of which a piece of plate was blown, because, although beneath the water line, it became softened by the overheating, caused by the flame from a furnace impinging so directly upon it as to keep up a continuous flow of steam, and prevent water remaining in contact with it.

Fig. 15, Plate XXVI., shows an exploded Butterley boiler, at Walsall, 1865, which was not intended to have more than 5 lbs. working pressure, and which was properly supplied with fittings and warning whistles to keep it safe. The whistle was afterwards found on the engine-house roof gagged with hemp, and within the engine-house was a self-registering clock-gauge, which showed the pressure must have run up above 20 lbs. before the explosion. As it is the only instance known of the exact pressure of an explosion, the clock-gauge is sketched on the diagram as of peculiar interest.

Fig. 16, Plate XXVI., is from Sir William Fairbairn's report on the explosion of the locomotive "Irk" at Miles Platting, in which he embodies so many useful experiments as to the strength of stays. It is a matter of satisfaction to record that, as an old investigator of the subject of boiler explosions, he much encouraged the writer as a beginner in col-

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lecting information, and also approved the form of illustration adopted by the writer which made the matter clear to enginemen and boiler-minders.

Fig. 17, Plate XXVI., Manchester, 1858, has a sad interest, as the explosion killed Mr. Forsyth, who was the first proposer of systematic inspection as the best means of preventing explosions. The boiler gave way while being caulked under steam testing.

Fig. 18, Plate XXVI., shows an early form of boiler adopted for steam carriages on common roads, when it was hoped they might prevent the necessity of railroads. It was excellent for the purpose of getting steam, but of so weak a shape that it burst by the twist given it when a wheel came off the coach at Glasgow, 1834.

Fig. 19, Plate XXVI., shows an explosion at Banbury in 1857, arising from the broken end of a connecting rod of a locomotive being pushed by the crank through the fire-box of the boiler. Its special interest to the writer is that he was in the train behind it, and was awakened from sleep by the burning coals coming up on the window.

Fig. 20, Plate XXVI., Dudley, 1867, is given as a specimen of the enormous size of many old balloon boilers. It is 22 feet diameter, and would make a good sized room.

Fig. 21, Plate XXVI., shows an explosion at Corbyn's Hall in 1862, which raised much discussion at the time, as the crown of the centre tube which was subsequently found in the down flue beneath, was at first missing. Shortness of water was the supposed cause, but it was afterwards found to have been what is called "drum-head" motion in the crown plate. The enlarged section at the bottom of the diagram shows that each varying pressure from the working of a steam hammer must have caused movement in the plate, soon producing a line of weakness, as in paper bent frequently, aided by the corrosion from the scale being constantly driven off by the frequent bending.

Fig. 22, Plate XXVI., shows the explosion of tube boilers, which were supposed free from danger.

The behaviour of the forces pent up in a boiler and other vessels when set at liberty is worthy of study.

The extreme violence of some boiler and other explosions have led to the supposition that steam sometimes assumes an explosive property, and such an idea is reiterated after any explosion more puzzling than usual. Professor Airy has demonstrated that a cubic foot of water heated to the temperature of steam at 60 lbs. pressure has the energy when liberated of 1 lb. of gunpowder. He points out that the store of steam contains but little energy, but the heated water is the source of destruction.

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In a boiler explosion the liberated steam and water immediately occupy a large space previously filled with air, and then as quickly condense and leave a vacuum in place of the plenum. The air has to pack itself away, and then returns to its place, which often causes walls and buildings to fall towards the scene of explosion.

Fig. 23, Plate XXVII., shows the comparatively small disturbance from the explosion of a vessel of steam. The air in normal condition is shown by equidistant crosses. The contents of the ruptured vessel occupy a space and drive some air away, the intruding air being represented by dots.

Fig. 24, Plate XXVII., shows how on the condensation of the steam the air rushes back to fill the space.

Fig. 25, Plate XXVII., shows the far greater effect from a vessel of heated water and steam. Far more air has to be packed away, which returns, Fig. 26, with greater violence after the condensation of the steam.

Fig. 27, Plate XXVII., shows the supposed effect of the explosion of gunpowder or gas, and Fig. 28 the return of the air to the space occupied, by the heated products of the explosion. In this case the residual products when cold occupy more space than the water from the condensed steam.

Fig. 29, Plate XXVII., shows the quicker action of dynamite, and the supposed wave of vibration which causes the peculiar shaking which is so destructive to glass. The writer was very close to the recent dynamite explosion at Westminster, and thus accounted for the number of windows broken and the ringing of the bells in the attics of his office.

Fig. 30, Plate XXVII., shows the different condition of things when a vessel of air explodes, which simply allows its contents to flow into atmosphere until an average is attained, and as no partial vacuum is found there is no rush back of air.

Fig. 31, Plate XXVII., shows the same when such a vessel explodes in a narrow tunnel, when the effect must be felt to a greater distance.

Fig. 32, Plate XXVII., shows an experimental apparatus for testing bands of light material spread round a bladder, which although not bigger than a man's fist, shook and broke the windows of the room when it was burst.

Fig. 33, Plate XXVII., represents another effect of "atmospheric impact," in the violent recoil of a pistol fired with a penny on the muzzle. It buried itself in the ground.

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Fig. 34, Plate XXVII., represents a further effect of the resistance of the air. Two gun barrels are screwed breech to breech, and the charge of powder is put in the usual place, with a wad and a bullet beside it. On firing it the bullet will be projected out with considerable violence, because the air in the other barrel will be so jambed by the sudden compression as to act as a breach.

EXPERIMENTAL EXPLOSIONS.

These have not very greatly assisted in the investigation of the causes of explosion. They have been more relied on in America than in England.

Fig. 35, Plate XXVIII., shows the result of a notable one by the Committee of the Franklin Institute in 1836, but on too small a scale for any safe deductions to be made from it.

A more interesting set were carried out by another Committee at Sandy Hook in 1872, on an old land boiler, Fig. 36, Plate XXVIII.; on a flat vessel to test staying, Fig. 37, Plate XXVIII.; and on an old marine boiler, Figs. 38 and 39, Plate XXVIII.

Others were conducted at Pittsburg by the same Committee. More lately some private experiments were made at the latter place, and Fig. 40, Plate XXVIII., represents the result of one, but their value is much diminished as they were conducted rather for private interests than scientific knowledge.

The experiments of Sir William Fairbairn on the strength of tubes wrought a revolution in boiler engineering, and upset the old Cornish rules that a tube of half the diameter equalled the strength of a shell of the same thickness.

Further experiments of more recent date showed the tubes to be rather less strong than did the experiments made by Sir William Fairbairn, and a comparison of the pressures at which some forty tubes failed in practice shows that they only bore half the pressure Sir William Fairbairn's formula gave. Fig. 42, Plate XXVIII., represents results of collapse of tubes.

It is more easy to predict the strength of a shell than a tube, because in the former the strain is in proportion to the thickness left, and it tends to draw itself into the best form for resistance; but in the latter the strength is as the square of the thickness, and being in "unstable equilibrium," it gets out of the circle, and very quickly loses its strength, as in Figs. 43 and 44, Plate XXVIII.

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Every now and then the idea is gravely revived that the usual mode of calculating the strength of cylinders is incorrect, and that the pressure upon the semi-circumference instead of the diameter should be taken, Fig. 45, Plate XXVIII., which is of course a mistake.

Fig. 46, Plate XXVIII., explains the reason why the longitudinal seams of a cylindrical boiler are more strained than the circumferential ones. If *a b* and *c d* represent portions of the shell of the boiler exposed to a strain tending to pull the boiler asunder in the direction of its length, they will have to support that amount of the strain on the area of the circular end of the boiler represented by the triangles *a e b-c e d*, but if *a b* and *c d* represent the same lengths of shell exposed to a bursting strain, they will have to resist an amount of strain represented by the length of one of them into the diameter of the boiler on the rectangle *a b c d*, which is exactly twice the area of the triangles *a e b-c e d*.

Fig. 41, Plate XXVIII., shows experiment of water thrown into a red hot boiler at Dudley, in the year 1850, without explosion.

Mr. Francis Galton, in his interesting papers on generic images, points out the danger of dwelling too much on the abnormal, and forgetting the far more numerous examples of the normal, which do not attract attention, and properly speaking, therefore, the newspaper account of any fatal railway accident should conclude with the statement that so many millions of people during the day reached their destination in safety.

Attention to so many boiler explosions should not permit the fact to be lost sight of that vast numbers of boilers work in safety, so that the number which fail are few indeed by comparison, but as there is nowhere any accurate list of the total number and variety of boilers employed, all statistics of boiler explosions are worthless as a means of comparison either between the number exploded and those which have proved safe, or between the relative merits of the various classes.

A curious sameness in the explosions is often observable like an epidemic in diseases. During the past year it has been among small upright or crane boilers, nearly a dozen of that class having failed.

The summary of the lessons gathered from all that is gone before is that all boilers, however good, may deteriorate until they burst, if due care is not taken to ascertain their condition from time to time. No boiler is free from the chance of explosion, and they have happened among those made by celebrated firms, worked by those of the highest repute or under the elaborate supervision of the public departments.

Insurance has been proposed as a remedy, but it is only useful if it is made the means of enforcing proper inspection.

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MYSTERIOUS THEORIES OF BOILER EXPLOSIONS.

It may be of interest to allude to the striking phenomena which have been supposed to be connected with boiler explosions.

Boiling by sudden jerks may be first alluded to, where water in a perfectly clean vessel can be heated far above the boiling point, and then suddenly started into steam with a jerk, as shown in Fig. 47, A and B, Plate XXIX. No boiler is sufficiently clean to allow of this. Each little roughness or rivet head acts as a nucleus to start a stream of steam bubbles, which effectually prevents this storage of heat in the water. This must not be confounded with the heating up of the whole of the water in a boiler while standing to the temperature of the steam, so that a great store of heat is extracted from the water in the shape of steam as the temperature falls. Fig. 48, A and B, Plate XXIX., shows how this can be exhibited in experiment.

Fig. 49, Plate XXIX., shows the apparatus for illustrating the "spheroidal condition" of water. The "spheroid" can be made to stand still over the heated part of the plate, but will burst into steam on the cooler part. It is believed by some that this may happen with the overheated side of a boiler. This must not be confounded with the effect illustrated in Fig. 50, Plate XXIX., where a stream of steam prevents contact of water.

Fig. 51, Plate XXIX., shows an easy way to illustrate the decomposition of steam. The steam from the kettle passes over red hot iron filings, which take up the oxygen, the hydrogen passing on to the end of the tube, where it can be lighted. This must not be confounded with cases of gas in boilers, where the blow-pipe has communicated with sewers of a town in streets saturated with leakage from gas pipes, as shown in Fig. 52, Plate XXIX.

In Fig. 53, Plate XXIX., is shown Sir W. Armstrong's hydro-electric machine, that should be well known in Newcastle-upon-Tyne, the place of its invention. The globules of water in the partially condensed steam cause sufficient friction against the boxwood jet to put them into electrical condition, and, being collected on the conductors, sparks may be extracted from it. This led some to suppose that scale can be prevented from forming by an electrical condition, as shown in Fig. 54, A and B, Plate XXIX., but it contains nothing to produce electrical action.

At the conclusion of the paper Mr. MARTEN showed and explained numerous experiments illustrating his remarks.

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Mr. A. L. STEAVENSON said, he had much pleasure in proposing a vote of thanks to Mr. Marten for his very interesting paper. A gentleman in Mr. Marten's position had an opportunity of accumulating facts such as no one else had, and out of that accumulation he had brought before them the salient points affecting explosions of boilers of every kind. The experiments as to concussion led him (Mr. Steavenson) to think very much of the effects which were met with after explosions in collieries. There were, no doubt, often appearances met with after explosions in collieries which they had great difficulty in accounting for; they found brick walls blown in one direction, and strong baulks of timber in another direction; and the effect of the concussion had, no doubt, much to do with these matters.

Mr. G. C. GREENWELL seconded the motion, and it was agreed to.

Mr. MARTEN thanked the meeting for the vote. He said, several of those present were, no doubt, perfectly familiar with many of the experiments which he had shown them, and yet had not seen them, and that was the reason why he had ventured to bring so many simple things before them.

The following paper by Professor W. STEADMAN ALDIS, M.A., "On Internal Stress in Cylindrical and Spherical Dams," was taken as read:—

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To illustrate M.r F. B Martens paper "On Explosions of Boilers and other Vessels."

EXPLOSIONS OF BOILERS AND OTHER VESSELS,
BEST MODES OF ILLUSTRATION.

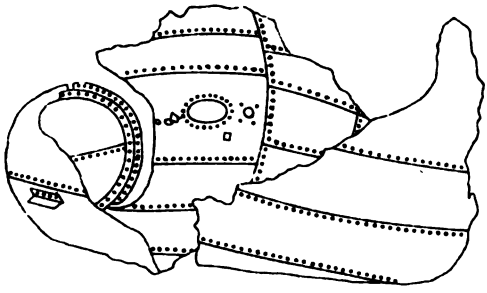

FIG. 1. MANCHESTER, 1848, SKETCH WHICH SUGGESTED VIEWS IN PERSPECTIVE.

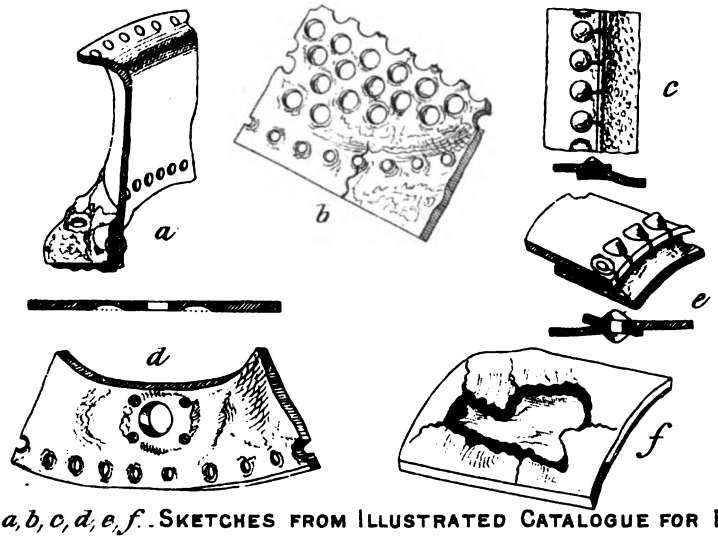

FIG. 2. *a, b, c, d, e, f.* SKETCHES FROM ILLUSTRATED CATALOGUE FOR EXHIBITION AT BRUSSELS OF INTERESTING FRAGMENTS.

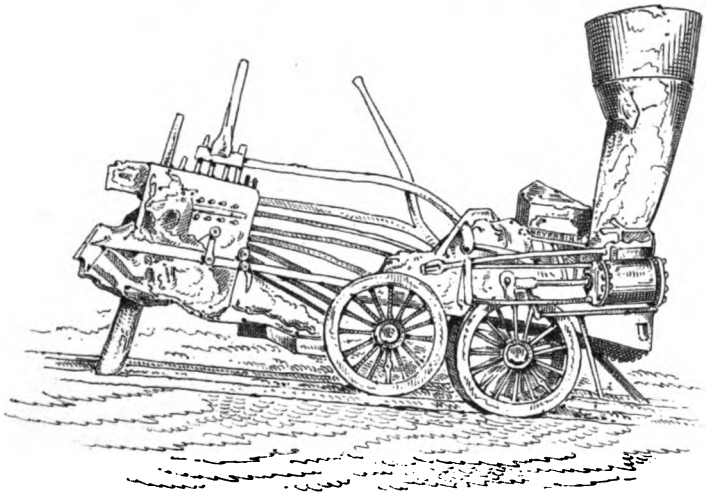

FIG. 3. — AMERICAN LOCOMOTIVE "NEVERSINK".

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To illustrate Mr. E.B. Marten's paper 'On Explosions of Boilers and other Vessels'.

Explosions of Boilers and other Vessels, Mode of Illustration.

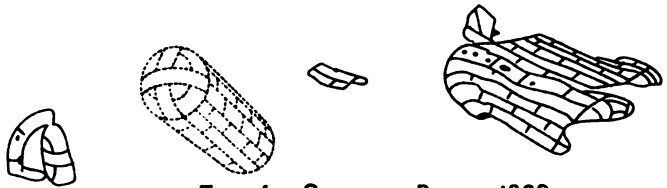

Fig. 4 _ Seaton Burn. 1860.

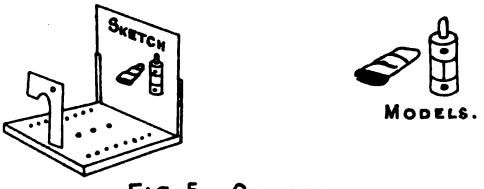

Fig. 5 _ Camera.

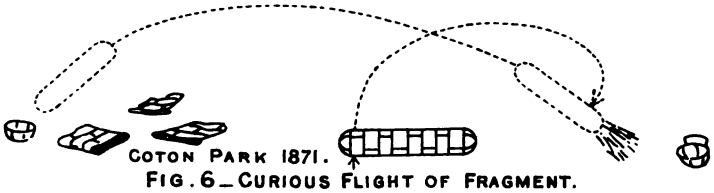

Fig. 6 _ Curious Flight of Fragment.

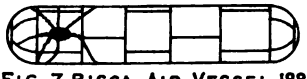

Fig. 7. Risca _ Air Vessel, 1882.

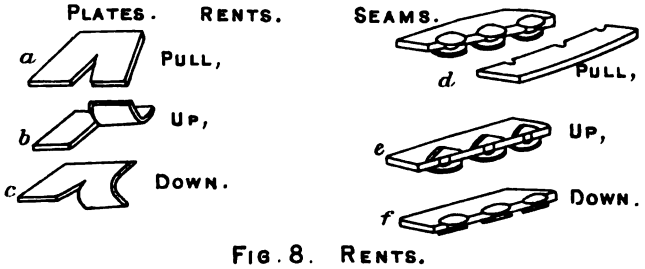

Fig. 8. Rents.

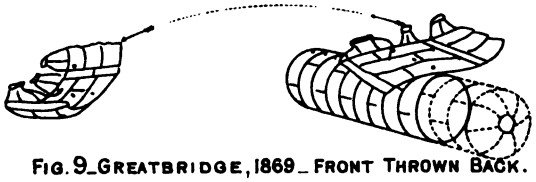

Fig. 9 _ Greatbridge, 1869 _ Front Thrown Back.

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To illustrate Mr. E. B. Marten's paper "On Explosions of Boilers and other Vessels."

Explosions of Boilers and other Vessels, Selected Cases of Explosion.

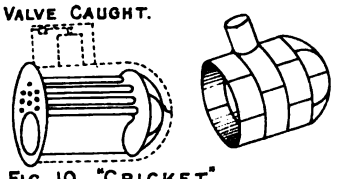


Fig. 10. "Cricket."

Fig. 11. Coffee Roaster, London, 1856.

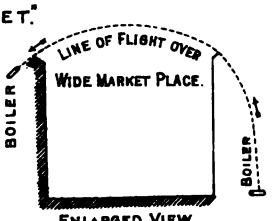


Fig. 13 Very Small Boiler.

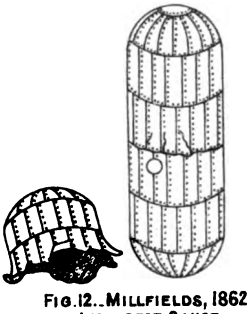


Fig. 12. Millfields, 1862, Incorrect Gauge.

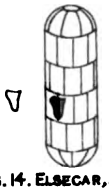


Fig. 14. Elsecar, Flame impinging on one place.

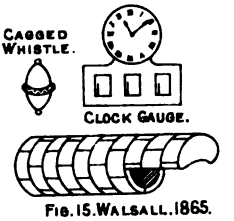


Fig. 15. Walsall. 1865.

Sir W. Fairbairn's Report, Fig. 16. "Irk" Loco: 1845.

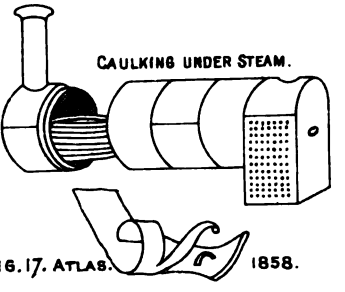


Fig. 17. Atlas. 1858.

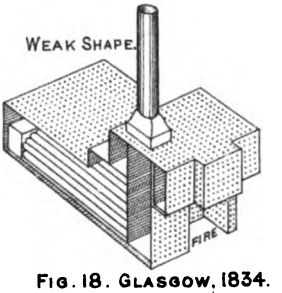


Fig. 18. Glasgow, 1834.

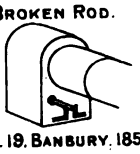


Fig. 19. Banbury. 1857.

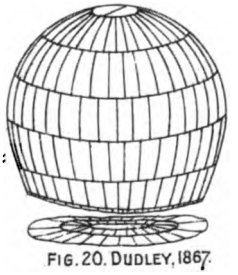
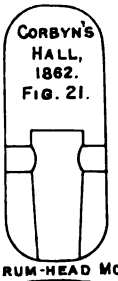
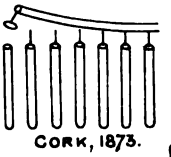


Fig. 20. Dudley, 1867.



Drum-head Motion.

Enlarged View Centre tube Crown.



Cork, 1873.

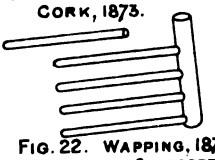


Fig. 22. Wapping, 1872, Failure of Supposed Safe Boilers.

Proceedings No. E1 of M&M.E. 1882-83.

Andw. Reid, Newcastle.

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To illustrate Mr E.B. Marten's paper "On Explosions of Boilers and other Vessels."

Explosions of Boilers and other Vessels,
Atmospheric Impact from Explosions.

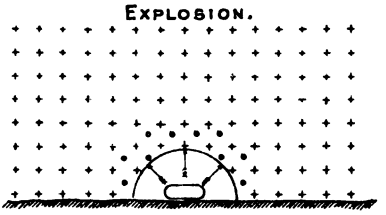

Fig. 23.—Steam.

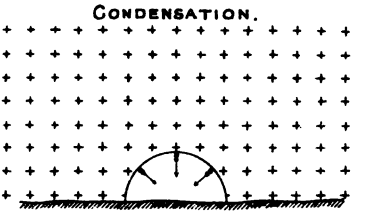

Fig. 24.—Vacuum.

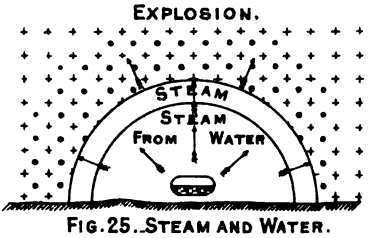

Fig. 25.—Steam and Water.

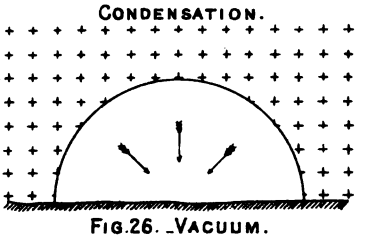

Fig. 26.—Vacuum.

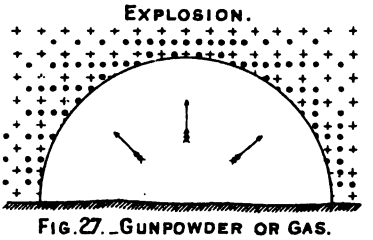

Fig. 27.—Gunpowder or Gas.

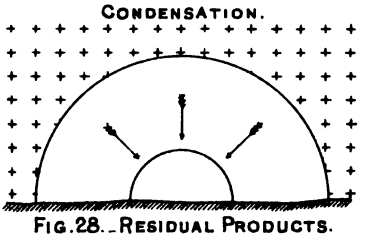

Fig. 28.—Residual Products.

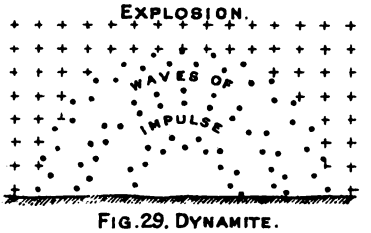

Fig. 29. Dynamite.

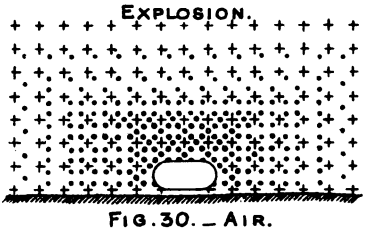

Fig. 30.—Air.

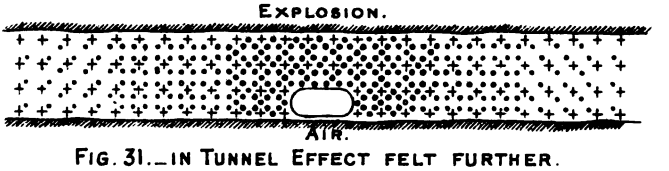

Fig. 31.—In Tunnel Effect felt further.

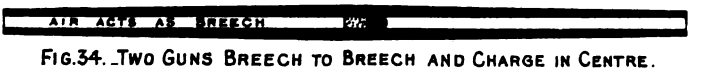

Fig. 34.—Two Guns Breech to Breech and Charge in Centre.

Fig. 32. Test Bag Burst with Air caused damage.

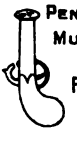

Fig. 33.—Recoil against Air.

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To illustrate Mr. E. B. Marten's paper "On Explosions of Boilers and other Vessels."

Explosions of Boilers and other Vessels, Experimental Boiler Explosions.

Fig. 35. Franklin Inst: 1836.

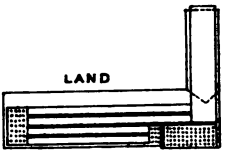


Fig. 36. Sandy Hook. 1872.

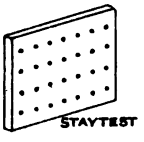


Fig. 37. Sandy Hook. 1872.

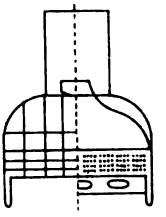
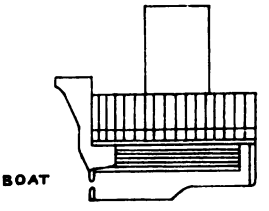


Fig. 38.



Sandy Hook. 1872. Fig. 39.

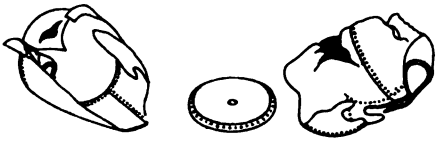


Fig. 40. Mun hall Valley. 1881. Pittsburg

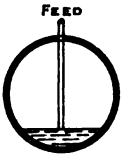


Fig. 41. Dudley, 1850.

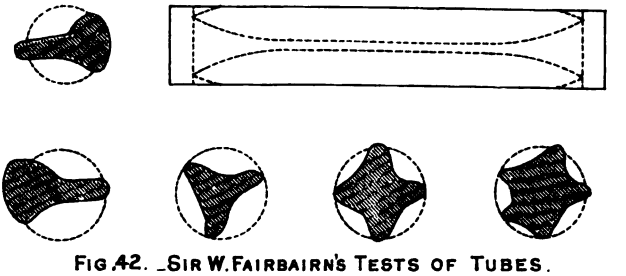


Fig. 42. Sir W. Fairbairn's Tests of Tubes.

Corrosion in Shell.

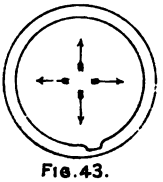


Fig. 43.

Corrosion in Tube.

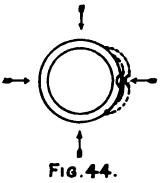


Fig. 44.

Calculation of Strength.

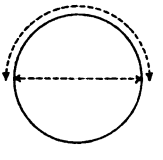


Fig. 45.

Comparison of Strains Lengthways and Across.

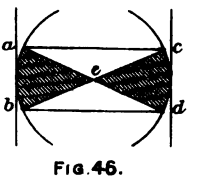


Fig. 46.

Andw. Reid, Newcastle.

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To illustrate M.r E.B. Marten's paper "On Explosions of Boilers and other Vessels."

EXPLOSIONS OF BOILERS AND OTHER VESSELS,

MYSTERIOUS THEORIES OF BOILER EXPLOSION.

SUDDEN BOILING.

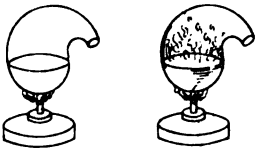

FIG. 47A FIG. 47B

ACCUMULATED HEAT.

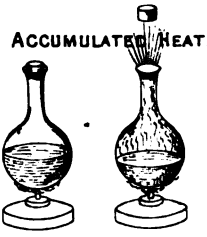

FIG. 48A FIG. 48B

SPHEROIDAL CONDITION OF WATER.

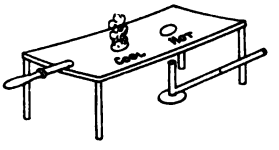

FIG. 49.

TOO MUCH HEAT IN ONE PLACE.

FIG. 50.

DECOMPOSITION OF STEAM.

FIG. 51.

GAS FROM SEWERS.

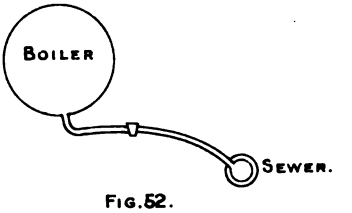

FIG. 52.

SPARK.

ELECTRICITY FROM STEAM.

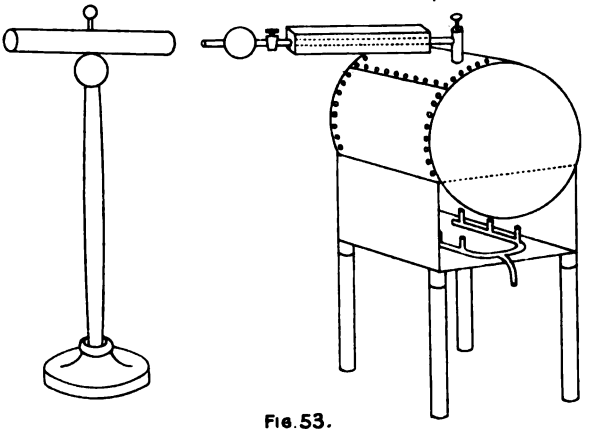

FIG. 53.

SUPPOSED SCALE PREVENTED.

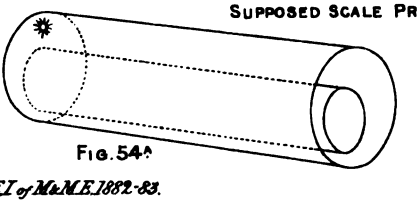

FIG. 54A

ENLARGED FIG. 54B

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ON INTERNAL STRESS IN CYLINDRICAL AND SPHERICAL DAMS.

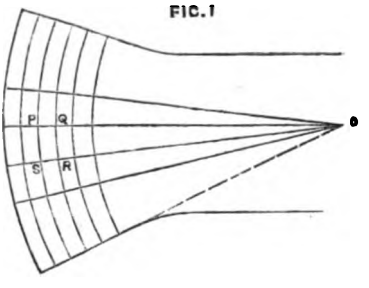
By Professor W. STEADMAN ALDIS, M.A.

The author's attention has been drawn by Professor Merivale to the question of the crushing stress between the different parts of a dam employed to shut off water from the working parts of a mine. It appears that mining engineers consider that the most advantageous method of constructing such a dam is to make it in the form of a portion of a sphere, the axis of symmetry of the portion being horizontal. In consequence of the greater difficulty of construction of a spherical dam it is not unusual in this district to make dams in the form of a portion of a circular cylinder whose axis is vertical.

The following investigations relative to the internal crushing stress at different points of such dams may be of interest to the members of the Institute:—

The cylindrical dam may be supposed to be constructed of a great number of co-axial cylinders, one within the other. If, through the common axis of these cylinders, a number of planes be drawn inclined to

FIG. 1



each other at very small angles, the solid body of the dam will be divided into a number of prism-like elements standing on bases, such as P Q R S, in the figure which represents a horizontal section of the dam.

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Fig. 2 is a representation of this prism-like element. The face

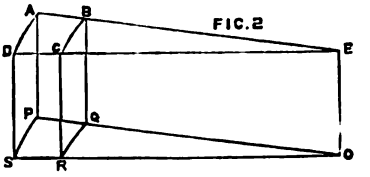

FIG. 2

P A D S is acted on by the pressure of the layer next outside pushing it towards O, the face B Q R C by the pressure of the layer inside pushing it outwards. The faces P Q B A and R C D S are acted on by pressures, which from symmetry may be assumed to be equal, and to act at right angles to their surfaces. These four pressures must be in equilibrium.

Suppose that the element of volume under consideration belongs to the nth cylindrical layer of the dam reckoning from the inside.

Let p_n measure the pressure per unit of area exercised by the inner layer outward, p_{n+1} that exercised by the outer layer inward, and t_n the

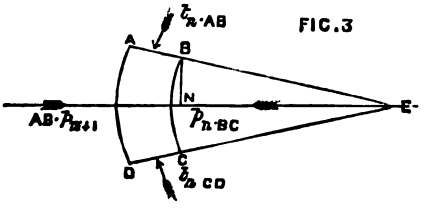

FIG. 3

stress per unit of area on each of the faces A Q and D R. The forces on the four faces are then proportional to

$$t_n \,.\, AB,\ p_n \,.\, \text{arc } BC,\ p_{n+1} \,.\, \text{arc } AD,\ t_n \,.\, CD.$$

Let E N bisect the angle A E D, and let B C be joined. E N is the direction of the action of the stresses on B C and A D; the portion of the stresses on A B and C D, which acts outwards, will, by a proposition known as the triangle of forces, be to either of the forces $t_n \,.\, AB$ as B C to E B.

Hence
$$t_n \,.\, AB \cdot \frac{BC}{EB} = p_{n+1} \,.\, AD - p_n \,.\, BC;$$

the arc B C and the chord being indistinguishable when the angle A E D is very small.

But $BC : AD :: r_n : r_{n+1}$, and $AB = r_{n+1} - r_n$.

Whence this equation gives:—

$$t_n (r_{n+1} - r_n) = p_{n+1} r_{n+1} - p_n r_n \quad . \ . \ . \quad (1).$$

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In actual practice t_n, as well as p_n, probably varies from layer to layer. The problem of determining its actual value at any point is therefore indeterminate, since there is only one equation to determine two quantities. The *average value* of t_n over the whole dam can be determined by supposing the element considered to represent the slice of the whole dam. If r, r' be the outer and inner radii of the dam, and t the average value of t_n, there must be substituted in (1) t for t_n, p for p_{n+1}, 0 for p_n, r for r_{n+1}, and r' for r_n. The formula then becomes—

$$t(r - r') = p r \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Or if $r - r'$, which is the thickness of the dam, be called k—

$$k t = p r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

The formula (3) agrees with a well-known formula giving the tangential stress in the case of a very thin surface in the form of a right circular cylinder which is exposed to the action of fluid pressure; the stress being a tension in the case of a flexible or rigid cylinder containing fluid *within* it, and a resistance in the case of a rigid cylinder empty within and exposed to the pressure of fluid *without*.

It will thus be seen that a similar formula holds for the *average* tangential stress in the case of a cylinder of sensible thickness.

The formula (1), expressed in the language of the differential calculus, gives—

$$t = \frac{d(p r)}{d r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4),$$

from which, if either t or p be assumed as any definite function of r—that is, if either the normal or tangential stress be assumed to change in any definite manner from point to point within the dam—the value of the other can be determined.

For instance, let t be assumed to vary directly as r, a supposition which will give t its greatest value at the outside, a not improbable result. Assuming $t = \mu r$, then—

$$\frac{d(p r)}{dr} = \mu r;$$

therefore

$$p r = \tfrac{1}{2} \mu r^2 + C;$$

and remembering that $p = 0$ at the inner surface, where $r = r'$,

$$p r = \tfrac{1}{2} \mu (r^2 - r'^2)$$

$$= \tfrac{1}{2} t \frac{r^2 - r'^2}{r}$$

Whence

$$t = \frac{2 p r^2}{r^2 - r'^2} \quad . \quad . \quad . \quad (5).$$

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If t be required not to exceed a certain value T,

$$\frac{2p\,r^2}{r^2 - r'^2} < \text{T will be required;}$$

therefore $$\frac{r^2 - r'^2}{r^2} > \frac{2p}{T},$$

or $$\frac{r'^2}{r^2} < 1 - \frac{2p}{T},$$

and $$\frac{r'}{r} < 1 - \frac{2p}{T}.$$

Whence k, the thickness, which $= r - r'$, must be at least equal to

$$r\left\{1 - \sqrt{1 - \frac{2p}{T}}\right\} \quad . \quad . \quad . \quad . \quad . \quad (6).$$

Turning now to the case of a spherical dam. Let A be the common

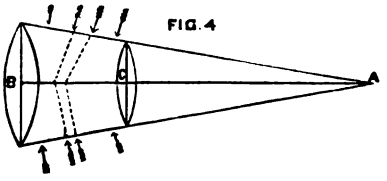

FIG. 4

centre of the external and internal surfaces, and let r_1, r be the internal and external radii.

With A as vertex, and any line A B as axis, imagine a right circular cone described with a very small vertical angle. This will cut off two small circular elements of area on the internal and external surfaces respectively, whose areas will be proportional to the squares of r_1 and r. The outer surface is pressed in by a pressure p per unit of area, and if x is called the radius of the small circle, the pressure on this circular element will be $p \cdot \pi x^2$.

The sort of decapitated sugar-loaf element of the dam which has been isolated is pressed symmetrically by the surrounding mass, and if t be the *average* amount of the thrust per unit of area on this element, the whole thrust will be $t \times$ area of surface of element. It may be noticed that, assuming the action of the surrounding mass to be always perpendicular to the conical surface, an assumption which the equality of action and reaction renders probable, the thrust at all points will be inclined to A B at the same angle, namely, the half vertical angle of the cone.

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The portion of the thrust at each point which helps to resist the external pressure will be obtained, in accordance with the triangle of forces, by diminishing the thrust in the ratio of x to r, and the whole resolved thrust outwards is therefore equal to

$$t \times \text{area of surface of element} \times \frac{x}{r}.$$

The area of the surface of a cone is one-half the length of the slant side multiplied by the circumference of the base. The area of the surface of the whole cone starting from A is therefore $\frac{1}{2} r \times 2\pi x = \pi x r$.

The radius of the small circle in which the cone cuts the inner surface is evidently to x as r_1 is to r, and therefore $= \frac{x r_1}{r}$; the circumference of this circle therefore equals $2\pi \frac{x r_1}{r}$, and the surface of the cone with A for vertex and this circle as base $= \frac{1}{2} r_1 \times 2\pi \frac{x r_1}{r} = \frac{\pi x r_1^2}{r}$.

Hence the surface of the element over which the thrust t is exerted is $\pi x r - \frac{\pi x r_1^2}{r}$; or, as it may be written, $\frac{\pi x}{r} (r^2 - r_1^2)$.

The resolved part of the whole thrust along A B is therefore

$$= \frac{t \pi x}{r} (r^2 - r_1^2) \times \frac{x}{r} = t \pi x^2 (1 - \frac{r_1^2}{r^2}).$$

Hence $$p \pi x^2 = t \pi x^2 (1 - \frac{r_1^2}{r^2});$$

therefore $$p = t (1 - \frac{r_1^2}{r^2});$$

or $$t = \frac{p}{1 - \frac{r_1^2}{r^2}} = \frac{p r^2}{r^2 - r_1^2} \quad . \quad . \quad (7).$$

This gives the average value of the stress; but, as before remarked in the case of a cylindrical dam, the value at different points may exceed or fall short of this.

The formula can be put into another shape, connecting t with the outer radius and the thickness:—

Let k be the thickness: then

$$k = r - r_1.$$

But from (7) $$r^2 - r_1^2 = \frac{p r^2}{t};$$

therefore $$r_1^2 = r^2 (1 - \frac{p}{t});$$

or $$r_1 = r \sqrt{1 - \frac{p}{t}}.$$

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Whence, since $k = r - r_1$,

$$k = r\left\{1 - \sqrt{1 - \frac{p}{t}}\right\} \quad . \quad . \quad . \quad (8).$$

which gives k in terms of r, p, and t.

It may be noticed that if k be very small compared with r the formula (7) reduces to a well-known formula, giving the relation between the tension and fluid pressure in the case of a thin spherical shell.

For (7) can be written $t = \frac{p r^2}{(r - r_1)(r + r_1)} = \frac{p r^2}{k(2r - k)}$; whence $kt = \frac{pr}{2 - \frac{k}{r}}$, which if $\frac{k}{r}$ be very small reduces to the formula in question, namely

$$kt = \tfrac{1}{2} pr \quad . \quad . \quad . \quad . \quad (9).$$

The investigation may be conducted in the following manner, analogous to that adopted in the case of the cylindrical dam:—In Fig. 4 may be supposed a series of concentric spheres, with A as centre, to be described at equal small distances k. By this means the conical wedge of the dam between B and C is divided into a number of small elements, each of which is something in the shape of a saucer of thickness k.

Any one of these saucer elements will be acted on by the thrust of the layer next outside it pushing it inwards; by the thrust of the layer next inside pushing it outwards; and, thirdly, by the thrust of the portion of the spherical shell to which it belongs surrounding the conical wedge, pressing it symmetrically round its rim. These forces together must be in equilibrium.

Let P Q R S be a section of this saucer-like element by a plane

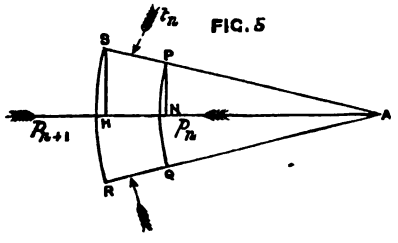

FIG. 5

through the axis of the cone: let A P $= r_n$, A S $= r_{n+1}$, the element being supposed to belong to the nth shell counting from within.

Let t_n be the average normal stress along the rim of the element, p_n and p_{n+1} the pressures on its inner and outer spherical surfaces respectively, all estimated per unit of area.

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Then if K be the area of the inner spherical surface, that of the outer will by the properties of similar figures be to K as r^2_{n+1} is to r_n^2—that is, it is $K \frac{r^2_{n+1}}{r_n^2}$. Hence the whole pressure on the outer surface is $p_{n+1} K \frac{r^2_{n+1}}{r_n^2}$ acting towards A, and the whole pressure on the inner surface is $p_n K$ acting outwards from A.

If P N and S H be drawn perpendicular to the axis of the cone, the area of the surface over which t_n is exerted is $\pi \cdot AS \cdot SH - \pi AP \cdot NP$.

But S H is to P N as A S to A P—that is, as r_{n+1} to r_n.

Hence the surface over which t_n is exerted

$$= \pi r_{n+1} \cdot \frac{r_{n+1}}{r_n} \cdot PN - \pi r_n \cdot PN$$

$$= \frac{\pi (r^2_{n+1} - r_n^2)}{r_n} \cdot PN.$$

Hence, as in the former method, the part of the whole value of t_n exerted on this rim, resolved parallel to A H

$$= t_n \cdot \frac{\pi (r^2_{n+1} - r_n^2)}{r_n} \cdot \frac{PN^2}{AP};$$

therefore $p_{n+1} K \cdot \frac{r^2_{n+1}}{r_n^2} - p_n K = t_n \cdot \frac{r^2_{n+1} - r_n^2}{r_n} \frac{\pi \cdot PN^2}{r_n}$.

But K ultimately $= \pi \cdot PN^2$. Hence is obtained—

$$\frac{p_{n+1} r^2_{n+1}}{r_n^2} - p_n = \frac{t_n (r^2_{n+1} - r_n^2)}{r_n^2},$$

or $p_{n+1} r^2_{n+1} - p_n r_n^2 = t_n (r^2_{n+1} - r_n^2) = t_n (r_{n+1} + r_n) \cdot k$ (10).

if k be the thickness.

The formula (10) shows the indeterminateness of the problem. If any law be assumed by which t_n changes with r_n, it will be possible, by taking equations similar to (10) for all the strata, to discover the value of t at any point. The equation (10) is in fact the only equation which connects two unknown quantities, the tangential stress and the radial stress in any stratum. This result is only what ought to be expected, since no materials of which the dam can be made will support stresses of the magnitude supposed without undergoing some change of form or volume, and the real value of the stress at any point will depend on the actual change of form of the element surrounding the point considered.

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The equation (10) will, however, give the same *average* value of t_n as that given in (7). This average value will be discovered by multiplying t_n by the area of the saucer edge over which it is exerted, adding all such products, and dividing the sum by the sum of the areas of the rings.

It has been seen that the area of the surface of the saucer edge over which t_n may be supposed to act is represented by $\pi (r^2{}_{n+1} - r_n^2) \cdot \frac{PN}{r_n}$.

It is also obvious that $\frac{PN}{r_n}$ is the same for all the strata, since P N increases in exactly the same ratio as r_n. Hence the area in question may be represented as $c (r^2{}_{n+1} - r_n^2)$.

Thus the average value of t_n is represented by the fraction,

$$\frac{c t_1 (r_2^2 - r_1^2) + c t_2 (r_3^2 - r_2^2) + \ldots + c t_n (r^2 - r_n^2)}{c (r_2^2 - r_1^2) + c (r_3^2 - r_2^2) + \ldots + c (r^2 - r_n^2)},$$

if n be the total number of layers.

But by means of equation (10), and omitting the factor c, which is common to the numerator and denominator, this reduces to

$$\frac{(p_2 r_2^2 - p_1 r_1^2) + (p_3 r_3^2 - p_2 r_2^2) + \ldots + (p_{n+1} r^2 - p_n r_n^2)}{r_2^2 - r_1^2 + r_3^2 - r_2^2 \quad + \ldots + \quad r^2 - r_n^2};$$

or since $p_{n+1} = p$ and $p_1 = 0$, to $\frac{p r^2}{r_1^2 - r^2}$, which is the value of t given in (7).

The equation (10) can be written in the language of the differential calculus:—

$$\begin{aligned} d (p r^2) &= t d (r^2) \\ &= 2 t r \, dr \quad \ldots \quad (11). \end{aligned}$$

Hence if t be assumed as any function of r, the integration and the complete solution of the problem are possible.

Two cases may be considered.

First, let t be assumed to be the same throughout. There is then obtained by integration,

$$p r^2 = r^2 t + C;$$

When $r = r_1$, $p = 0$;

therefore $0 = r_1^2 t + C$;

or $C = - r_1^2 t$.

Hence $p = \frac{(r^2 - r_1^2) t}{r^2}$ or $t = \frac{p r^2}{r^2 - r_1^2}$.

And if r be the external radius, p is the external pressure, and the formula (7) previously obtained is repeated.

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Secondly, let t increase as any power of r, say r^n, so that $t = \mu r^n$ where μ is some constant.

Hence $$\frac{d(pr^2)}{dr} = 2\mu r^{n+1};$$

therefore $$pr^2 = \frac{2\mu r^{n+2}}{n+2} + C.$$

When $r = r_1$, $p = 0$;

therefore $$0 = \frac{2\mu r_1^{n+2}}{n+2} + C;$$

and $$pr^2 = \frac{2\mu}{n+2}(r^{n+2} - r_1^{n+2}) \quad . \quad . \quad (12).$$

Hence the greatest value of t, which $= \mu r^n$, r being the external radius,

$$= \frac{\frac{1}{2}(n+2)pr^{n+2}}{r^{n+2} - r_1^{n+2}} = \frac{\frac{1}{2}(n+2)p}{1 - \left(\frac{r_1}{r}\right)^{n+2}} \quad . \quad . \quad . \quad (13).$$

The materials must therefore be such as to resist a stress of this magnitude without sensibly yielding.

A priori reasons of some force might be suggested in favour of the assumption that t varies as r.

In this case the greatest value of t per unit of area

$$= \frac{\frac{3}{2}p}{1 - \left(\frac{r'}{r}\right)^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad (14).$$

From (14) may be deduced

$$1 - \left(\frac{r'}{r}\right)^3 = \frac{3p}{2t};$$

therefore $$\left(\frac{r'}{r}\right)^3 = 1 - \frac{3p}{2t};$$

or $$r' = r\sqrt[3]{1 - \frac{3p}{2t}}.$$

Whence $$k = r - r' = r\left\{1 - \sqrt[3]{1 - \frac{3p}{2t}}\right\} \quad . \quad . \quad (15),$$

which gives k in terms of r, p, and t.

A similar deduction from (13) gives

$$k = r\left\{1 - \sqrt[n+2]{1 - \frac{(n+2)p}{2t}}\right\} \quad . \quad . \quad (16).$$

It may be added that the equations (4) and (11) are substantially the same as equations (1) of Article 273 and (1) of Article 275 in Rankine's "Applied Mathematics." From these equations Rankine appears to deduce more definite results than have been derived from them in this paper.

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Equation (4) of this paper may be altered by the assumptions

$$p = x + y$$
$$t = x - y,$$

into the form

$$\frac{d\{(x+y)r\}}{dr} = x - y,$$

which may be written

$$\frac{d(xr)}{dr} + \frac{d(yr)}{dr} = x - y.$$

Rankine really *assumes*, although the fact is somewhat disguised, that *the complete* solution of this equation is to be obtained by separating the two parts, and solving separately the two equations

$$\frac{d(xr)}{dr} = x$$

$$\frac{d(yr)}{dr} = -y,$$

which give, by processes easy to those acquainted with the integral calculus, the results

$$x = a$$
$$y = \frac{b}{r^2},$$

where a and b are constants.

Hence undoubtedly *one solution* of the single equation (4) is given by

$$p = x + y = a + \frac{b}{r^2}$$

$$t = x - y = a - \frac{b}{r^2},$$

where a and b can be determined by the known values of p at the inner and outer surface.

With all deference, however, to the great authority of Rankine, the *assumption* referred to does not seem to have any warrant from a mathematical point of view, and the solution given by him must stand or fall according to its agreement, or the reverse, with observed facts.

A similar remark applies to Rankine's solution of equation (1) of Article 175 in "Applied Mechanics."

It may he mentioned that the results of this paper relating to cylindrical dams may be also applied to the question of the strength of tubbing in any case where the external pressure on the tubbing may be assumed to be uniform at all points in a horizontal level, and to be directed symmetrically towards the centre of the shaft.

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An able paper on this latter question, by the late Mr. J. J. Atkinson, is to be found in Vol. IX. of the Transactions of the Institute. Mr. Atkinson, however, accepts Professor Rankine's deduction of two equations out of one, which, as just explained, the author does not feel it necessary to do.

The formulæ (3) and (6) give the thickness necessary for a cylindrical dam exposed to a given pressure of water p, t and T being the average crushing stress, and the greatest crushing stress on a certain hypothesis, respectively in a tangential direction. If T_1 be the greatest stress which the materials are capable of supporting without collapsing, t and T must not exceed a certain fraction of T_1, as, for instance $\frac{1}{10}$ of T_1. (Twisden's "Practical Mechanics," Art. 9.)

Thus in a cylindrical dam the minimum thickness k, consistent with safety, on the supposition that the *average* stress alone need be considered, will be given by

$$k = \frac{10\,p\,r}{T_1} \quad . \quad . \quad . \quad . \quad . \quad (17).$$

If the supposition be adopted that the tangential stress increases uniformly from the inside outwards, k will be given by the formula—

$$k = r\left\{1 - \sqrt{1 - \frac{20\,p}{T_1}}\right\} \quad . \quad . \quad . \quad . \quad (18).$$

On similar suppositions the minimum thickness of a spherical dam of the same materials can be deduced from the formulæ (8) and (15), and will be respectively:—

$$k = r\left\{1 - \sqrt{1 - \frac{10\,p}{T_1}}\right\} \quad . \quad . \quad . \quad . \quad (19),$$

and

$$k = r\left\{1 - \sqrt[3]{1 - \frac{30\,p}{2\,T_1}}\right\}$$

$$= r\left\{1 - \sqrt[3]{1 - \frac{15\,p}{T_1}}\right\} \quad . \quad . \quad . \quad . \quad (20).$$

Professor Merivale has given the writer the details of a spherical dam at Creusot. The head of water outside is 215 metres. The pressure consequently per square centimetre is the weight of 21·5 cubic metres of water—that is, the measure of p in kilogrammes per square centimetre is 21·5.

The material of the dam is pitch pine, the ultimate strength of which is 457 kilogrammes per square centimetre. The measure of T_1 is therefore 457 in the same units as p. Hence

$$\frac{p}{T_1} = \frac{21{\cdot}5}{457}.$$

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The value of r in the case of the dam in question is 5·04 metres.

Hence from (19), if the stress be considered uniform throughout the dam, the thickness ought to be

$$= 5{\cdot}04 \left\{ 1 - \sqrt{1 - \frac{215}{457}} \right\}$$

$$= 5{\cdot}04 \left\{ 1 - \sqrt{\frac{242}{547}} \right\}.$$

By a table of logarithms the value of $\sqrt{\frac{242}{457}}$ is easily found to be nearly ·7277.

Hence the thickness required on this supposition

$$= 5{\cdot}04 \times {\cdot}2723 = 1{\cdot}372 \text{ metres.}$$

On the second supposition the thickness required is by (20)—

$$= 5{\cdot}04 \left\{ 1 - \sqrt[3]{1 - \frac{322{\cdot}5}{457}} \right\}$$

$$= 5{\cdot}04 \left\{ 1 - \sqrt[3]{\frac{134{\cdot}5}{457}} \right\}$$

$$= 5{\cdot}04 \left\{ 1 - {\cdot}66517 \right\}$$

$$= 5{\cdot}04 \times {\cdot}33183$$

$$= 1{\cdot}687 \text{ metres.}$$

The inner radius ought therefore to be

$$5{\cdot}04 - 1{\cdot}687 = 3{\cdot}353 \text{ metres.}$$

the value actually employed being 3·34 metres.

The construction of this particular dam appears therefore to be in accordance with formula (20).

A cylindrical dam in the same place, if the stress be supposed uniform, would by formula (17) require a thickness

$$= 5{\cdot}04 \times \frac{215}{457} = 2{\cdot}371 \text{ metres;}$$

while, if the stress be supposed to vary uniformly from within outwards, the thickness must be by formula (18)—

$$= 5{\cdot}04 \left\{ 1 - \sqrt{1 - \frac{430}{457}} \right\}$$

$$= 5{\cdot}04 \left\{ 1 - \sqrt{\frac{27}{457}} \right\}$$

$$= 5{\cdot}04 \left\{ 1 - {\cdot}24306 \right\}$$

$$= 5{\cdot}04 \times {\cdot}75694$$

$$= 3{\cdot}814 \text{ metres.}$$

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Hence, on the supposition of uniform distribution of the stress, the thicknesses of a spherical and cylindrical dam should respectively be 1·372 and 2·371 metres; while, on the supposition of stress uniformly increasing outwards, the thicknesses should be 1·687 and 3·814 metres.

A cylindrical dam requires therefore on either supposition a much greater thickness for safety than a spherical dam.

The form of dam most frequently adopted in this district is, on the information of Mr. J. B. Simpson, a simple rectilinear barrier. If plenty of material be employed, this form of dam will doubtless resist the direct pressure of the water. Mr. Simpson says that leakage round the edges is the usual way in which such dams become ineffective. Without venturing on an opinion as to the relative merits of different forms, a question into which expense, difficulty of construction, and many other considerations enter, the writer may point out that spherical and cylindrical dams will tend to prevent this leakage much more satisfactorily than a simple straight-across barrier. Increased pressure of water will tend to tear the latter away from its bearings by bending the solid body of the dam inwards, while, in the same case, cylindrical or spherical dams will be forced more tightly against the solid walls from which they spring.

Mr. G. C. GREENWELL proposed a vote of thanks to Professor Aldis for his carefully prepared paper, in which were a great many calculations which would have to be studied before any discussion could take place.

Mr. E. F. BOYD seconded the vote of thanks. He said there were very few who would take the trouble Professor Aldis had done in making the mathematical calculations which were found elaborated in the paper; and they ought to feel more especially indebted to him as he was not immediately connected with the coal trade.

The vote was carried by acclamation.

Mr. GREENWELL'S paper on "The Duration of the Coal of Great Britain and Ireland" was then announced to be open for discussion,

When Mr. G. C. GREENWELL said, the paper was based upon statistical facts, and he did not know that a very great amount of discussion would alter those facts. The questions that were raised were more for private thought and study than for public discussion, and he would be quite content to leave the paper in the hands of the members for their careful consideration.

The meeting then concluded.

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PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 9TH, 1883, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

A list of persons nominated as officers for the year 1883-84, was submitted by the Council in accordance with Bye-law 19.

The following gentlemen were elected, having been previously nominated:—

ASSOCIATES—

Mr. WILLIAM HILL, Colliery Agent, Carterthorne Colliery Offices, Witton-le-Wear.

Mr. JOHN R. WILSON, Swaithe, near Barnsley.

Mr. W. J. PHILLIPS, Ansley Hall Colliery, Atherstone.

STUDENTS—

Mr. RALPH RICHARDSON, Field House, West Rainton, Fence Houses.

Mr. ARTHUR D. MILTON, Sherburn House, Durham.

Mr. ROBERT R. LISHMAN, 33, Claypath, Durham.

Mr. R. S. ANDERSON, Elswick Colliery, Newcastle-on-Tyne.

Mr. J. T. PEASE, Loftus Mines, Cleveland.

The following were nominated for election at the next meeting:—

ORDINARY MEMBERS—

Mr. CHARLES EDWARD RHODES, Mining Engineer, Carr Houses, Rotherham.

Mr. ARTHUR SACKVILLE BOUCHER, La Salada Puerto Bertio, E de Antioquia, U.S. of Columbia, South America.

Mr. C. C. LEACH, Bedlington Collieries, Northumberland.

STUDENTS—

Mr. FRANK ROBERT SIMPSON, Hedgefield, Blaydon-on-Tyne.

Mr. EDWARD HEADLY HUTT, Usworth Colliery, *via* Washington Station, R.S.O., County Durham.

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There being no papers to read, the PRESIDENT said, the paper by Mr. E. F. Melly "On the Anthracite Coal of South Wales" was open for discussion. Mr. Melly, he was sorry to say, could not attend, but if anyone wished for further information on the subject Mr. Melly would be glad to give it.

No remarks being offered, the PRESIDENT said, the next paper to be discussed was that by Mr. E. B. Marten "On Explosions of Boilers and other Vessels." He was glad to see Mr. Marten present, and he asked if he wished to say anything to supplement his paper.

Mr. E. B. MARTEN said, that there had been very few experiments on the strength of boilers, and Mr. Longridge informed him that those which he had made were not published, but in a letter he remarks that Sir William Fairbairn's experiments, alluded to in Figure 42, Plate XXVIII., were made on tin vessels of a small diameter, and were hardly to be taken as very trustworthy, excepting as to one thing, not known before, that the strength of the flue tube was inversely dependent upon its length. Mr. Fletcher had, in answer to a request, called his (Mr. Marten's) attention to experiments made on a test vessel constructed after the explosion of the "Thunderer," at Portsmouth, the outcome of which was that screwed stays in a plate have not their full strength if the plate altered its shape, for when the plate began to bulge, the rounded side let go its hold. There were some experiments not yet complete, as to the comparison of ordinary flue tubes and the strength of corrugated flues. These results were not in his possession, but if the Institute used their influence, they might be obtained as recording experimental research. In his paper he alluded to the electrical apparatus of Sir William Armstrong, and he now added that Sir F. Abel, in his lecture before the Institution of Civil Engineers "On the Application of Electricity to Explosive Purposes," stated that this same mode of generating electricity was most effectual; it had been used for exploding, torpedoing, and mining, and at sea was unaffected by the damp atmosphere when used in an open boat.

Mr. J. A. G. ROSS said that he had gone into calculations as to the spheroidal condition of water, and had found that if the temperature of the plates was raised very much above 212 degrees, water, dropped on them in an ordinary gentle way, did not touch them; but that if water were dashed on, the result was that, in a second or two, it was flashed into steam, and he felt sure that was a cause which might account for a great number of explosions. Take a Cornish boiler, for instance; if water fell below the flue, and a portion of the plate about 50

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feet long by 20 or 25 inches broad by ½ inch thick was rendered red hot, he had made a calculation showing that 10 lbs. of water at 212 degrees, dashed upon this would be flashed into steam, which would be quite sufficient to raise the pressure in an ordinary Cornish boiler, 5 feet diameter by 25 feet long, from 30 lbs. to about 70 lbs. Mr. Marten called attention to mysterious cases of explosions; but to his mind most of these explosions could be traced to want of a sufficient margin of strength, caused either by age or an increase of the original pressure the boiler was constructed to withstand; whereas the factor of safety ought to be increased according to the age of the boiler. With respect to the hydro-electric machine, he said that the electricity shown by Mr. Marten was the frictional electricity developed by steam rushing out of a boiler. That was not the sort of electricity they had to fear. If they had two iron plates in two electrical conditions there must be a deterioration in one of the plates, even in the same plate a current of electricty might be set up. That electricity gradually reduced the plate in thickness, and ultimately rupture took place if the deterioration was not stopped in time. He thought Mr. Marten, with the very great experience he had had in the construction and inspection of boilers, might have given the Institute more information with respect to the methods which should be adopted to prevent boiler explosions. Mr. Marten in his paper only gave two lines as to the cure; he said, "insurance has been proposed as a remedy, but it is only useful if it made the means of enforcing proper inspection." Many methods had been proposed, and recently a bill had been brought before Parliament to ensure some amount of safety in boilers, by compelling users to employ suitable men, and enforcing some kind of examination. That bill had been thrown out, he understood to a large extent by the influence of boiler makers, who were afraid, if such conditions were imposed upon boiler minding, that it would lead people to use gas engines. That was a mistake The safer they made boilers, the surer would be the foundation on which boiler using would be carried. No notice had been taken in the paper of what were called Fox's corrugated tubes, which were receiving considerable attention from the Admiralty. At the Leeds Forge Company's works, tubes of a certain diameter were put under pressure, and an ordinary flue gave way at 200 lbs. pressure per square inch, while a corrugated flue did not yield till pressed to 1,000 lbs. per square inch. If that was correct he thought no tubular boiler should go with a plain flue. Mr. Marten did not tell the Institute what he suggested as to inspection, whether it should be Government inspection, or inspection by companies, or scientific inspection by experts.

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If he were to do so, his long connection with one of the oldest Boiler Inspection and Insurance Companies, namely, the Midland, would render his opinion of considerable value to the members.

Mr. LAWRENCE said, he thought Mr. Ross had somewhat mistaken Mr. Marten's paper, which was to bring before the members a series of very interesting experiments, and not to show how explosions could be prevented. Mr. Ross said that a gallon of water dashed upon a hot plate would account for some of the boiler explosions. He (Mr. Lawrence), however, thought the boiler must have a poor safety-valve to allow a gallon of water coming upon a hot plate in the usual way of feeding the boiler to explode it. In his opinion, the grand cause of all boiler explosions was that the boilers were too weak. Very much also depended upon external examination, which, he was sorry to say, could not be sufficiently made in plain cylindrical boilers. Splits in the plates, starting from the rivet holes, were very serious defects, and no boiler could be said to be properly inspected unless the seams are all carefully examined and the splits recorded, so that the boiler may be repaired before the seam becomes too much weakened. If the boilers were examined on the outside, what was going on in the seams could be more easily detected. Again, with regard to stopping these cracks by so-called stop rivets, he would like to ask Mr. Marten if he considered this a satisfactory method of repairing them? He had seen three or four of these rivets put in one plate, and the boiler put to work again, and he thought this could not be considered a complete or satisfactory repair. With respect to the Risca air-receiver, figure 7, Plate XXV., which was intended to stand 400 lbs. pressure of compressed air, and gave away at a pressure of about 390 lbs., it struck him that the cast-iron man-hole was the cause of the explosion. It was perhaps strong enough to have stood the pressure under a low temperature, but the temperature of the receiver was 350 degrees; and he thought the cause of the explosion was that the heat had caused the cast-iron to expand and split, when of course it ceased to strengthen the hole.

Mr. JOHN DAGLISH remarked, that his experience of Fox's tubes did not dispose him to go so far in their praise as Mr. Ross. He believed their manufacture had greatly improved of late, but certainly at one time they did not give very favourable results. Whether it was in the making of the corrugations that the iron itself was deteriorated, or whether it was that the sediments got into the corrugations he did not know; but certainly there had been several cases where they had failed very rapidly in ordinary wear and tear. There was no doubt as to their strength, provided they did not wear so fast.

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Mr. Ross concurred in what Mr. Daglish had said. Corrugating the flues put a tremendous strain upon the iron, such as very few brands of iron would stand. Whatever laminations there were showed themselves; but this had been quite overcome by the use of homogenous or steel plates. With an iron plate the corrugation caused very great strain upon the welds of the bloom, and if there was the slightest lamination in the plate, the heat playing through the flues developed a blush, and this blush resulted in the deterioration Mr. Daglish referred to. If a collapse did take place the corrugations allowed the plate to come down without tearing, but if a plain flue came down it must yield.

Mr. MARTEN said, the points raised in the discussion were interesting and important. The subject was so exceedingly wide that one could extend one's remarks almost in any direction. He wished he could place before them the little window in a boiler through which he, from day to day, had studied how the tubes behaved when the water was high or low, or when they were unduly heated. Mr. Ross had alluded to the spheroidal condition of water. He (Mr. Marten) brought this experiment before the Institute because it was one which was, to a certain extent, connected with boilers, and because boilers were always getting overheated, more or less, if they did not get red hot. Mr. Ross was quite right. If he had a plate of the size mentioned, and it was red hot, it might produce the amount of steam stated if all the heat could be imparted to the water at once; but in the ordinary way of feeding a boiler the water would creep up the side and gradually cool it, and it was seldom the whole of the heat could be taken out quickly enough to produce much sudden increase of steam. In the ordinary practice the water did not dash over the hot plates, but gradually rose against them, and the heat was carried off quietly, and danger would only arise from a sudden covering of the plate. The usual factor of safety used to be 6, it had now come down to 5, and even to 3 if everything was in good order. It was necessary not only to see that all things were good, but that the plates were, he might say, comfortable, that is really in repose without undue strain. He knew a boiler seven feet diameter, nearly half an inch thick, not in the least worn, which burst at only 50 lbs. pressure, whilst a boiler taken out of the same seating, eleven feet in diameter, worked for many years at 70 lbs. pressure, although in many places it was as thin as a sixpence. The original one, however, was made of exceedingly tough plates, just adapted for the work they had to do; and the new boiler was made of plates of a very hard quality of iron, which could not bear the serious strain of expansion from the great heat on the one side, and the comparative

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coolness of the water on the other; these plates had more of the nature of glass, and that was the reason they would not bear the work like those of the old boiler. The electric machine which he had exhibited to the members was to show that the electricity of steam had nothing to do with evaporation. Sir William Armstrong thought at first that the mere act of evaporation produced electricity; but that had not been proved. It was merely the friction of the globules of water against the wooden orifice. Mr. Ross was perhaps right as to electricity or galvanism increasing corrosion. The Bill brought before Parliament (he was not aware it had been thrown out) was not drawn in the interests of the boiler makers, but had been entirely framed from the workmen's point of view. Parliament had passed an Act under which every explosion was to be investigated, and it was thought that time should be given to see the result before anything further was done. Already 29 explosions of boilers had been investigated, and the reports were published at a small cost, and were easily attainable; and in the course of a year or two they would record a mass of information which would justify perhaps further legislation. He did not think any Parliamentary action, or any action on the part of boiler makers, would prevent Gas Engines being used in large towns where the inconvenience attendant on the use of steam was great; but he had not complete information as to how many Gas Engines had supplanted steam engines in towns. With regard to Fox's tubes he once had feared that the elasticity caused by the corrugation would have prevented the tubes acting as stays between the ends of the boiler; but subsequent experiments had proved to him that the pressure on the more vertical parts of the corrugation had a tendency to draw the tube together and increase its staying power. With regard to inspection, his impression was that its value consisted in its being the means of obtaining true and thorough information of the state of the boiler and of the nature of the deterioration it was subjected to. With respect to the Risca explosion the only way to arrive at any conjecture as to its origin was to join all the pieces together again, and to see where the first rent took place. That had been done, and it was certain that the rent commenced at the man-hole. It was not that cast-iron was used, but that there was not so much cast-iron in the section of the man-hole piece as to be equivalent to the amount of wrought iron which had been cut out of the shell. The ring would have been better if made of the same material as the shell; but it would have been better still if the man-hole had been put at the end. Stop rivets were often used; they were better than nothing, as they stopped the rent; but all repairs that did not restore the strength of the boiler should be looked upon with great caution.

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The PRESIDENT moved a vote of thanks to Mr. Marten for his kindness in attending the meeting. He was glad to see that the general tone of opinion seemed to be that the main points to make a boiler safe were to get a good boiler, and to watch it well. A boiler should be good and well looked after.

The motion was agreed to.

The PRESIDENT said, the next paper to be discussed was that "On Two Systems of Working the Main Coal at Moira, Leicestershire," by Mr. W. S. Gresley.

Mr. W. H. HEDLEY said, the present method produced better results than the former method; but, having regard to the large proportion of coal stated to be lost or wasted, it seemed to him there was even yet considerable room for improvement. Looking at the tables given by Mr. Gresley, he found that 38 per cent. of the thickness of coal worked was left behind, lost. He failed to see why so large a proportion of the coal actually dealt with should be lost in working. Moreover, he saw that there was a distinct portion of coal, nearly 3 feet in thickness, overlying the 10 feet of coal which was dealt with, and separated from it by bands of stone and coal, which together, made a total thickness of 5 feet 4 inches. Although the cover was considerable, nearly 150 fathoms, yet, judging from his experience of seams somewhat similarly situated in this district he should expect if the 3 feet coal was worked away more or less in advance, the 5 feet 4 inches might serve to form a roof for working the 10 feet afterwards; and in this way the 3 feet of coal, of which under the present system probably none was recovered, would also be got, and thus something like 20 per cent. more of the entire seam would be realized.

The PRESIDENT said, Mr. Gresley was not present to answer the question, and therefore it would be well to adjourn the discussion. It appeared that the 38 per cent. at the present time was a great improvement upon the 60 per cent. formerly lost. Still there was a great amount of loss, and Mr. Gresley might be able to explain the reason.

The PRESIDENT said, the next paper to be discussed was that "On Internal Stress in Cylindrical and Spherical Dams," by Professor W. STEADMAN ALDIS.

Professor ALDIS said, if there were any point in the paper about which any member felt a difficulty, he would try to make it clear. A straight-

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across dam might be sufficient where there was a small head of water, but where there was a great head of water it would be better to construct a spherical or cylindrical dam.

The PRESIDENT said, he did not think the general practice in this district had been to construct flat dams, as Professor Aldis seemed to think. They generally put in cylindrical dams, which were a great deal better than flat ones. He did not think anyone who had to deal with heavy pressures would put in flat dams. Probably the spherical was as much superior to the cylindrical dam as the cylindrical dam was superior to the flat dam.

Professor ALDIS said, it would possibly require more skill and involve greater expense to build a spherical dam in the first instance, but when erected such a dam would be by far the most efficient.

Mr. MARTEN said, he had put in spherical cylindrical dams, but not at very high pressure, and he noticed they pressed themselves into the sides, and therefore must have gone a little flatter. The spherical dam was formed without difficulty, each brick being arranged on the surface and marked. He asked if the President had ever observed a cylindrical dam get flatter?

The PRESIDENT—No. They are generally put in with such a considerable margin of strength that they rarely move. If any leakage occurred, it was at the top and bottom, tending to prove the superiority of the spherical dam, which would, under pressure, squeeze itself against the support in all directions. He moved a vote of thanks to Professor Aldis for his paper, which, he said, was upon a subject of great importance to the mining country at large.

Mr. JOHN MARLEY seconded the motion, and it was agreed to.

The meeting then concluded.

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PROCEEDINGS.

GENERAL MEETING, TUESDAY, JULY 3RD. 1883, IN THE TOWN HALL, BARROW-IN-FURNESS.

GEORGE BAKER FORSTER, ESQ., PRESIDENT, IN THE CHAIR.

ABOUT eighty members of the Institute assembled in the Town Hall, Barrow-in-Furness, the majority of them having arrived in the town on the previous day.

The MAYOR OF BARROW (John Fell, Esq.), in welcoming them, said—Before proceeding to the business for which they had met together, he desired to express, on behalf of himself and other burgesses of the borough, the gratification they felt at their town having been selected for a visit by the members. He considered it a great compliment, and hoped that they would find many objects and places of interest amongst the numerous extensive manufactories, works, and mines to repay them for their trouble. Every facility would be afforded them for the purpose. He proposed to hold a Conversazione, in the Town Hall, on Wednesday evening, at which it would give him great pleasure to see all present, as the meeting would not be at all formal, but one of a purely friendly and social character. To-day the members would, after the business of the meeting, be taken by special train to the Barrow Hæmatite Steel Company's works, after inspecting which they would return to luncheon. Probably it would not be possible to examine many of the details at the works, but he had arranged for specimens of the minerals, manufactures, etc., to be exhibited at the Conversazione.

The PRESIDENT asked the members present to join with him in returning their hearty thanks to the Mayor for his kind reception, also to the many friends who had taken so much pains to make their visit pleasant and give them an opportunity of inspecting the numerous objects

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of interest and beauty in the district. The care which had been taken in preparing the programme showed that the people of Barrow had determined to give them a hearty welcome, which he was sure all would appreciate, and he hoped they would enjoy their visit and find it pleasant and profitable.

The SECRETARY then read the following paper, by Mr. VINCENT W. CORBETT, "On Water-gauge, Barometer, and other Observations taken at Seaham Colliery during the time the Mandlin Seam was sealed up."

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ON WATER-GAUGE, BAROMETER, AND OTHER OBSERVATIONS TAKEN AT SEAHAM COLLIERY DURING THE TIME THE MAUDLIN SEAM WAS SEALED UP.

By V. W. CORBETT.

An explosion occurred at Seaham Colliery on the 8th September, 1880, occasioning the loss of 164 men and boys, and causing immense damage to part of the colliery workings and to the timber, etc., in the downcast shaft.

As this paper will be illustrated by plans and diagrams, it will be necessary in the first instance to give as briefly as practicable a description of the colliery and its workings.

The downcast shaft is 14 feet diameter and 300 fathoms deep, and is divided by a wooden brattice; the west side of the brattice is termed No. 1 Pit, the east side No. 2 Pit.

No. 1 Pit works the Hutton Seam of coal to the south and south-east, the coals being hung on at a depth of 255 fathoms; No. 2 Pit works the Hutton Seam to the north and north-east, the hanging on being at a depth of 281 fathoms in the Harvey Seam; from this seam a drift is driven cutting a trouble running east and west and winning the Hutton seam at the north side of it. The upcast shaft (No. 3 Pit) is 14 feet diameter and 270 fathoms deep. The seams worked to this pit are the Hutton Seam towards the west, the Maudlin Seam towards the north and north-east, and the Main Coal Seam is worked also by means of a staple sunk about 231 yards north-west of this pit; this seam lies 32 fathoms above the Hutton Seam; all these coals being hung on at the Hutton Seam level at a depth of 253 fathoms.

The workings are ventilated by means of two underground furnaces, assisted by the heat of the Nos. 1 and 2 Pits' underground boilers. Plate XXX. shows the arrangement of shafts, furnaces, drifts, boilers,

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seams of coal, etc., and Plate XXXI. shows the plan of the workings. The average quantity of air ventilating the whole of the workings, engine houses, stables, etc., is about 320,000 cubic feet per minute.

The accident occurred at about 2·30 a.m. on the morning of the 8th September. Owing to damage to the shafts some time elapsed before there was any communication with the workings. Subsequently it was ascertained that several fires existed, namely, in the old engine-house, No. 1 Pit, the coal was on fire; No. 1 Pit engine-house was on fire; various other fires were discovered and were gradually extinguished. The work of recovering the bodies was pushed on as fast as possible, but, owing to the number of falls on the rolleyways, it was not until the 1st October that the last district, the east-way in the Maudlin Seam, was explored; it was then discovered that a large fire existed in some temporary stables. This occurrence led to the sealing up of the Maudlin Seam workings. On the 3rd October a commencement was made to seal up this seam by temporary stoppings of wood, after which brick ones were put in, two of which were in the intake and one in the return air-course. Half-inch iron pipes were inserted through all these stoppings for the purpose of attaching water-gauges. Before midnight on the same day all these stoppings were completed. In the beginning of December a little gas was occasionally found in the return air-course in the Low Main Seam (these workings are shown by red lines on Plate XXXI.) not far distant from the No. 3 stopping, and as the Maudlin and Low Main Seams at this point are within a few feet of each other, it was possible that gas out of the Maudlin might be finding its way through the strata, and thus into the waste; it was therefore considered advisable to place in the Low Main Seam some additional stoppings, which were completed on the 11th, and the Maudlin Seam workings may be considered to have been hermetically sealed from that date.

When the Maudlin Seam workings were thus closely sealed up, the interior might be assumed to be a large gasometer and the readings of the water-gauges show clearly the difference between the atmospheric pressure prevailing outside the stoppings, and the pressure of the gases confined in the sealed up workings.

In order fully to understand the plans and diagrams illustrating this paper, it may be as well to minutely describe them, together with the arrangements that were made to carry out the experiments.

Plate XXXI., as before stated, represents a general plan of the workings, A being the downcast and B the upcast shaft. The method of

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ventilation is shown thus—the roads coloured blue are the in-take air-courses, and those coloured pink are the return air-courses, or waste. Stoppings were placed at 1 and 2 in the in-take of the Maudlin Seam, and at 3 and 4 in the return air-course. Water-gauges were placed at each of these stoppings, and the observations at these water-gauges (recorded as Nos. 1, 2, 3, and 4 water-gauges in the first four lines of the diagrams) along with the barometer and other readings, taken every hour, form the basis of this paper.

Through stopping No. 3 a 9-inch pipe was inserted with a bend turned upwards on which a valve was placed. This was loaded with a weight which would allow gas to escape when it reached a certain pressure behind the stopping. This was done lest any undue accumulation of gas should take place to an extent which might endanger the security of the stoppings. As, however, will be observed by the readings of the water-gauge at its side, no pressure of any consequence ever did occur.

The gas-check was taken in another part of the pit, in the No. 3 Pit, Hutton Seam workings, at about a mile distant from the stoppings. As will be seen by Plate XXXI., a gallery C (coloured black) about 50 yards long, leading from the return air-course to the goaf, was kept open so that a man could traverse it. This goaf might be said to be free in many directions to give off gas into the workings, but most of the galleries abutting on the goaf were more or less crept, whereas the gallery C was perfectly open.

This gallery C was used in much the same way as the tube of a barometer, to indicate the distance from the waste at which gas was found in the gallery. Every hour a man went in with a safety-lamp and noted the distance from the waste at which he first observed gas in the lamp, and these readings are given by means of the line marked Gas-ch. in the diagrams. Of course when the gas disappeared nothing more could be observed; when the line is at the top and registers straight over a certain space, it indicates that during that period of time there was no gas in the gallery. Again, when the gas came so freely out of the goaf as to be carried away by the air-current 50 yards distant, the diagram shows a straight line over a certain space at the bottom, which indicates that there was gas the whole length of the gallery. The lines marked respectively 2. Ba., 3. Ba., and Su. Ba. in the diagrams, indicate the three barometrical readings taken—one at No. 2 stopping shown by 2. barometer, the second at No. 3 stopping shown by 3. barometer, and the third

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at the surface shown by surface barometer. The barometers in use at the different points had not been adjusted up to the 8th of May, 1881—but on that day they were adjusted—it will be observed that almost up to that date the barometer at No. 3 stopping registered higher than the one placed at No. 2 stopping, but after the adjustment, the instrument at No. 2 stopping registered higher than the one placed at No. 3 stopping. The 1. The., 2. The., 3. The., and Su. The. in the diagram show four thermometrical readings—the first taken from an instrument placed at No. 1 stopping; the second from one placed at No. 2 stopping; the third from one placed at No. 3 stopping; and the last from one placed on the surface. The two bottom divisions are devoted to the direction of the wind and its force in miles per hour, indicated by a self-registering instrument kindly lent by Mr. L. J. Crossley, F.R.A.S., to the Meteorological Council, and placed by them at Seaham Harbour.

The following statement will explain the speed of the wind:—

When calm the velocity is about	...	...	...	2	miles per hour.
Light air	„	...	...	... 5	„
Breeze	„	...	...	... 10	„
Gentle breeze	„	...	...	... 15	„
Moderate „	„	...	...	... 20	„
Fresh „	„	...	...	... 27	„
Strong „	„	...	...	... 35	„
Moderate gale	„	...	...	... 42	„
Fresh „	„	...	...	... 50	„
Strong „	„	...	...	... 60	„
Whole „	„	...	...	... 70	„
Storm „	„	...	...	... 80	„
Hurricane	„	...	...	... 90	„

The only other observation taken was a reading of a thermometer placed inside the 9-inch pipe at No. 3 stopping, this was registered once a day. The readings of this instrument are not shown on the diagrams, but the following is a statement of the heat registered:—

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					Degrees.
From January	1st, 1881, to January	31st	...	...	70
„ February	1st		...	...	70¼
„ February	2nd to February	28th	...	...	70
„ March	1st to March	5th	...	...	69
„ March	6th to March	10th	...	...	70
„ March	11th to March	19th	...	...	69
„ March	20th to March	23rd	...	...	70
„ March	24th to April	10th	...	...	69
„ April	11th to April	20th	...	...	69½
„ April	21st to May	11th	...	...	70
„ May	12th to June	3rd	...	...	69
„ June	4th to June	17th	...	...	70
„ June	18th to June	20th	...	...	69
„ June	21st to June	24th	...	...	70

Three men, working in three separate shifts, were appointed to make observations at these several points in the workings, the readings of the barometer and thermometer at the surface being made separately.

As before stated, the distance between the points where the water-gauges and barometers were placed is about a mile from the gallery where the gas-check was made, and the stoppings 3 and 4 were not on the same level as 1 and 2, consequently, there was a lapse of time of about forty minutes between the commencement and termination of each hour's observations. Absolute simultaneousness of registration, therefore, was not attained, and it will be as well to recollect this in forming deductions, some of which are founded on readings of extreme minuteness. Referring to the diagrams, the space between the dark vertical lines represents a day, the light vertical lines dividing it into twenty-four equal spaces representing hours. The dark horizontal lines in the diagram represent inches in the four water-gauge readings and the three barometer readings, 20 yards in the gas-check readings, and inches in the barometer readings, the dotted dark horizontal lines at the top indicate a state of equilibrium between the air outside the stoppings of the four water-gauges and the gas in the sealed up workings, the space between each two horizontal lines is sub-divided by faint lines into tenths, each such division representing two yards in the space devoted to the gas-check.

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Therefore, the observations taken consist of:—

The readings of a water-gauge placed at	No. 1 stopping ...	marked	1. W. G.
„	„ „ No. 2 „ ...	„	2. W. G.
„	„ „ No. 3 „ ...	„	3. W. G.
„	„ „ No. 4 „ ...	„	4. W. G.
„	the gas check	„	Gas-ch.
„	thermometer at No. 1 stopping ...	„	1. The.
„	„ „ 2 „	„	2. The
„	„ „ 3 „	„	3. The.
„	„ surface	„	Su. The.
„	barometer at No. 2 stopping	„	2. Ba.
„	„ „ 3 „	„	3. Ba.
„	„ surface	„	Su. Ba.
Direction of the wind.			
Velocity of „			

The comparisons it is here proposed to call attention to are:—

1.—A comparison between the No. 3 water-gauge and No. 3 barometer.

2.—A comparison between the No. 2 water-gauge and the gas-check.

3.—A comparison between the No. 3 water-gauge and the gas-check.

4.—A comparison between the No. 3 barometer and the gas-check.

For the purpose of this paper it is perhaps now unnecessary to draw attention to all the observations taken, but three of the most clearly defined instances of the fluctuations of pressure have been taken for comparison.

First Instance.—From Saturday, the 5th of February, to and with Sunday, the 13th of February, 1881, shown on 256, 257, 258 pages.

Second Instance.—From Monday, the 21st of March, to and with Sunday, the 27th of March, 1881, shown on 271, 272 pages.

Third Instance.—From Saturday, the 14th of May, to and with Sunday, the 22nd of May, 1881, shown on 288, 289, 290, 291 pages.

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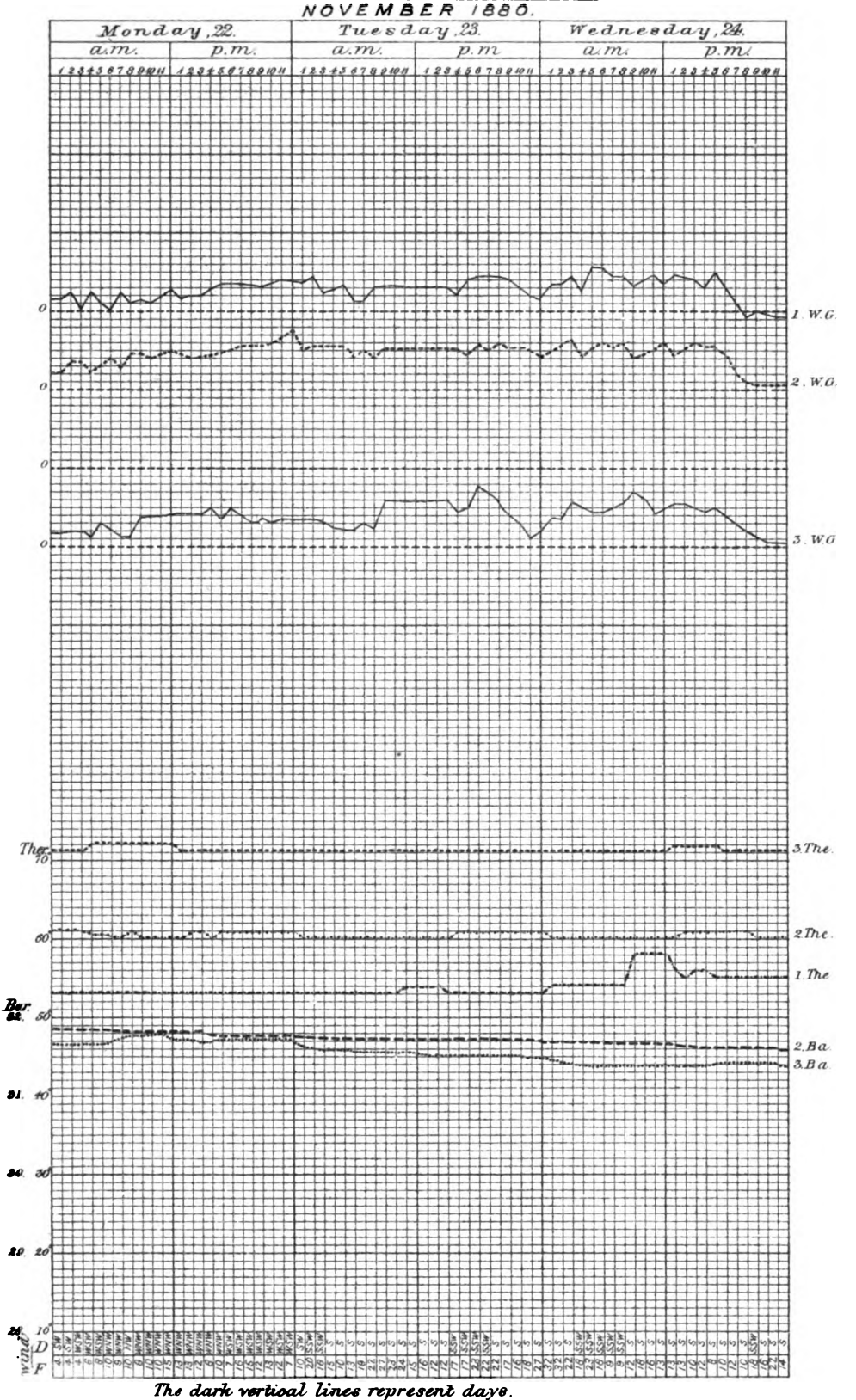
To illustrate Mr Corbetts paper.

NOVEMBER 1880.



The dark vertical lines represent days.
The light " " " hours.
The dark horizontal lines represent one inch of water or mercury 10° Fahrenheit and 20 Yards in the Gas check.

Proceedings No. E1 or M&ME 1887-83.

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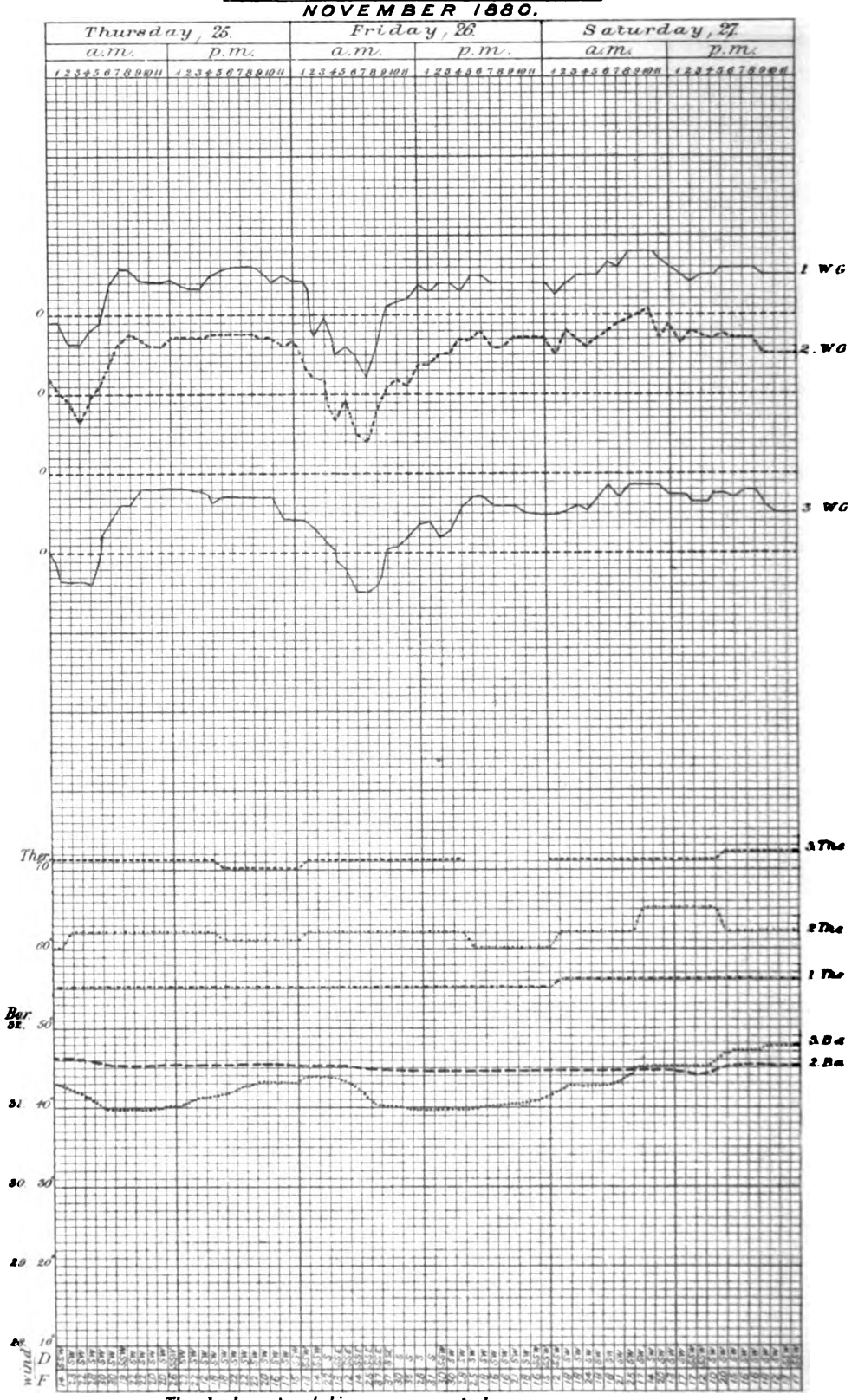
To illustrate Mr. Corbett's paper.

NOVEMBER 1880.



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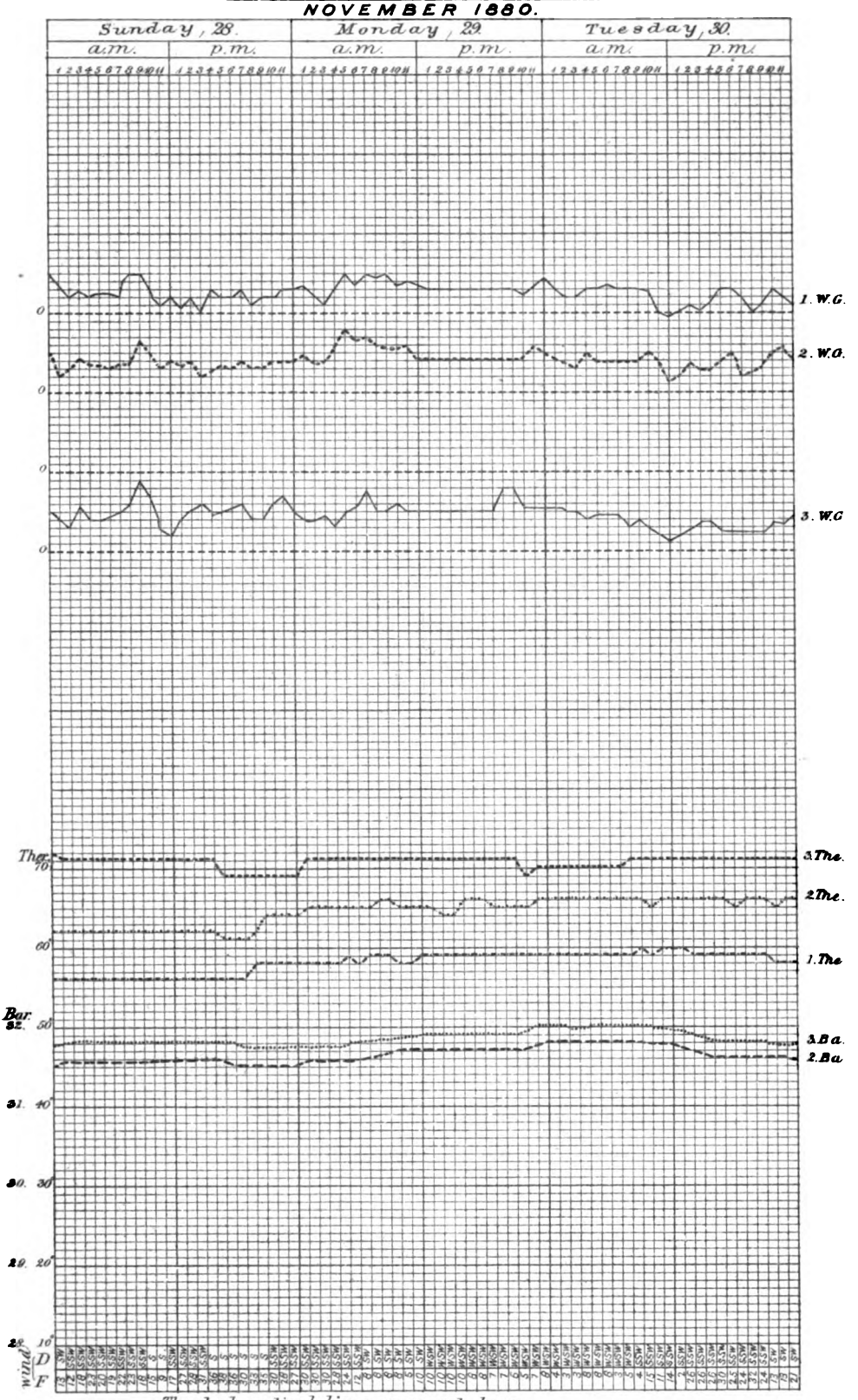
NOVEMBER 1880.



The dark vertical lines represent days.
The light " " " hours.
The dark horizontal lines represent one inch of water or mercury
10° Fahrenheit and 20 Yards in the Gas check.

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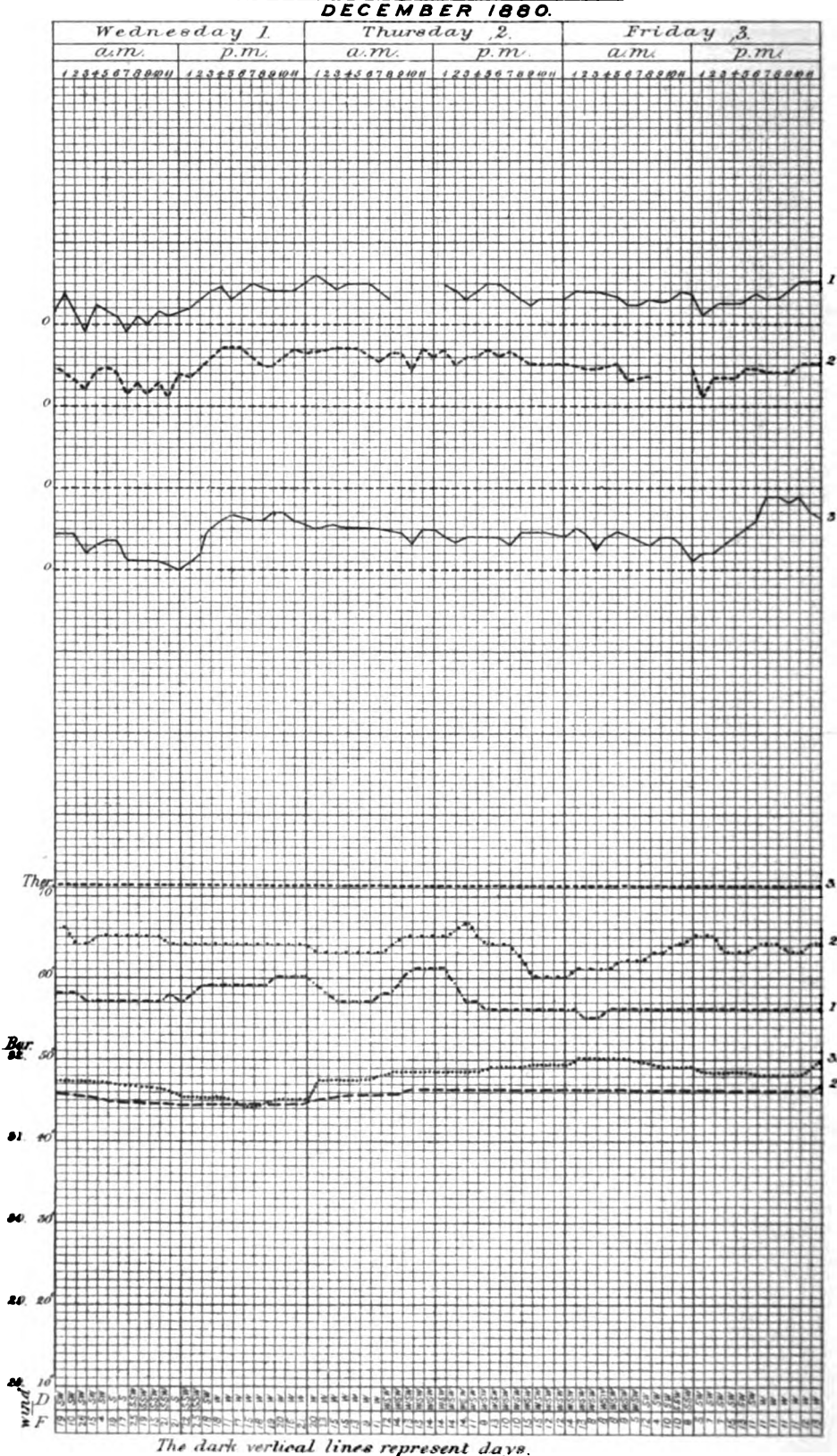
And. Reid, Newcastle

To illustrate Mr Corbetts paper.

DECEMBER 1880.



The dark vertical lines represent days.
The light " " " hours.
The dark horizontal lines represent one inch of water or mercury.
10° Fahrenheit and 20 Yards in the Gas check.

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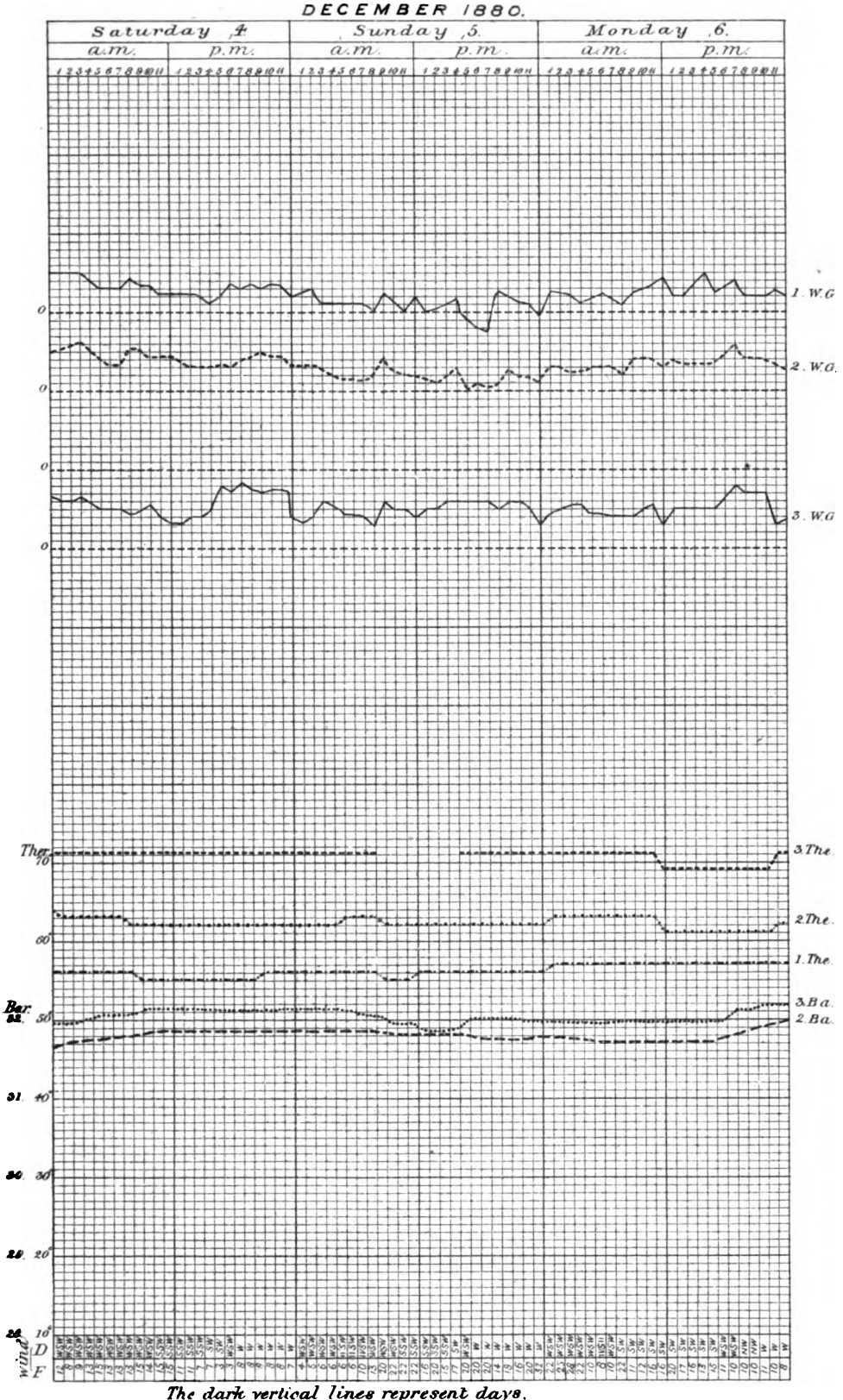
To illustrate Mr. Corbett's paper.



The dark vertical lines represent days.
The light " " " hours.
The dark horizontal lines represent one inch of water or mercury
10° Fahrenheit and 20 Yards in the Gas check.

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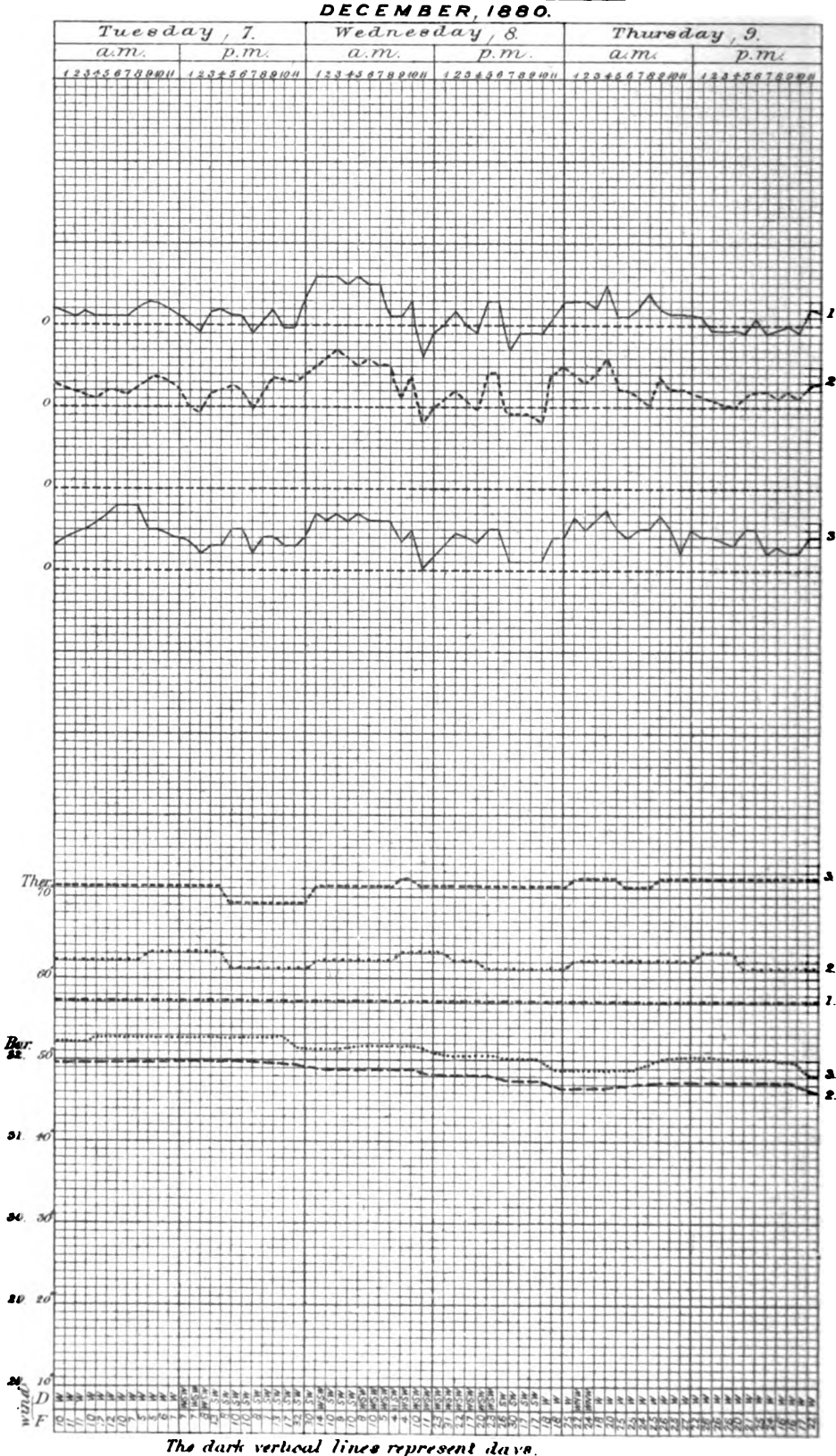
To illustrate Mr. Corbett's paper.



The dark vertical lines represent days.
The light " " " hours.
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10° Fahrenheit and 20 Yards in the Gas check.

Proceedings No. E1 of M&ME 18[illegible]83

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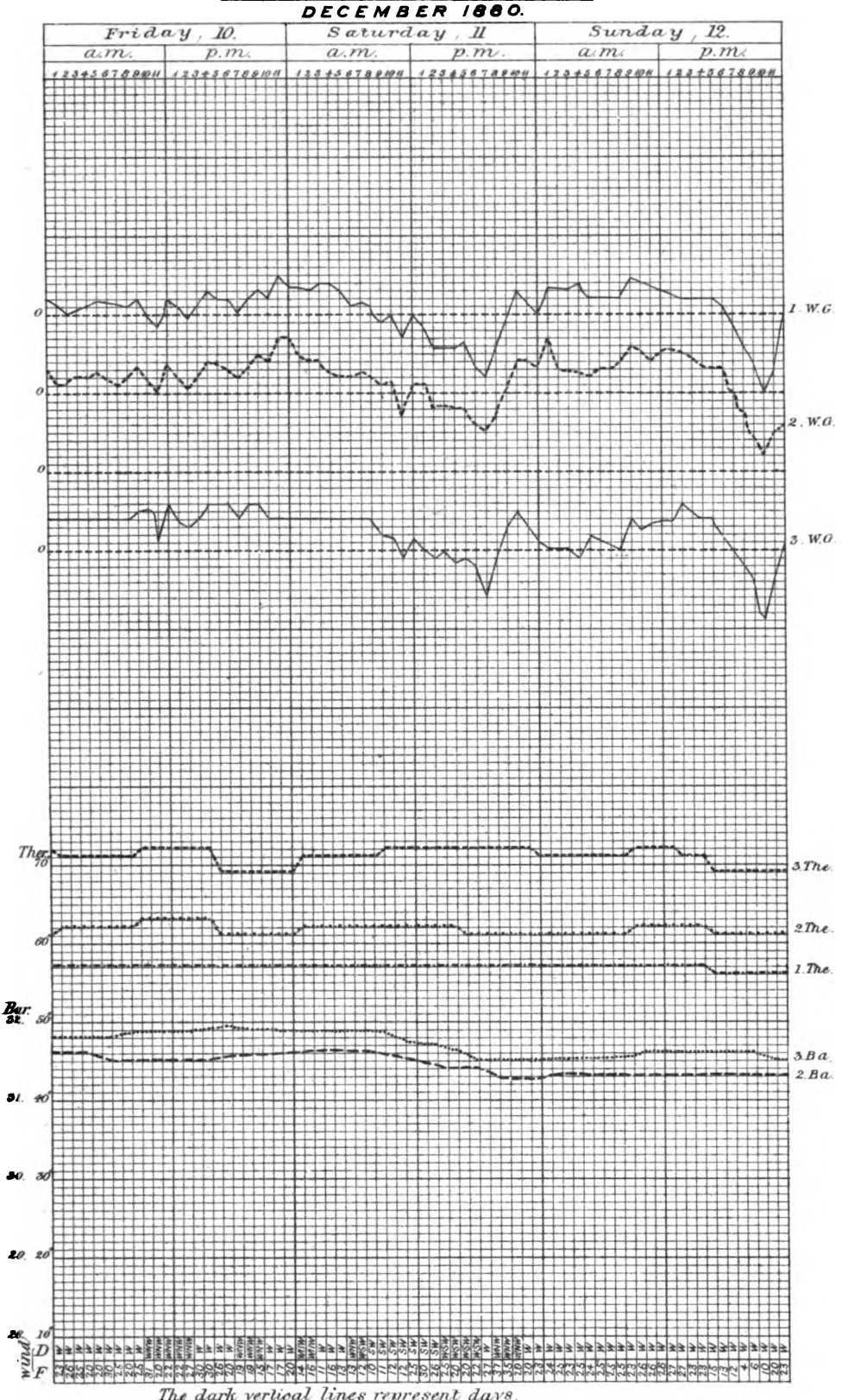
To illustrate Mr. Corbett's paper.

DECEMBER 1880.



The dark vertical lines represent days.
The light " " " hours.
The dark horizontal lines represent one inch of water or mercury
10° Fahrenheit and 20 Yards in the Gas check.

Proceedings N° E.1 of Mech. E. 1882-83.

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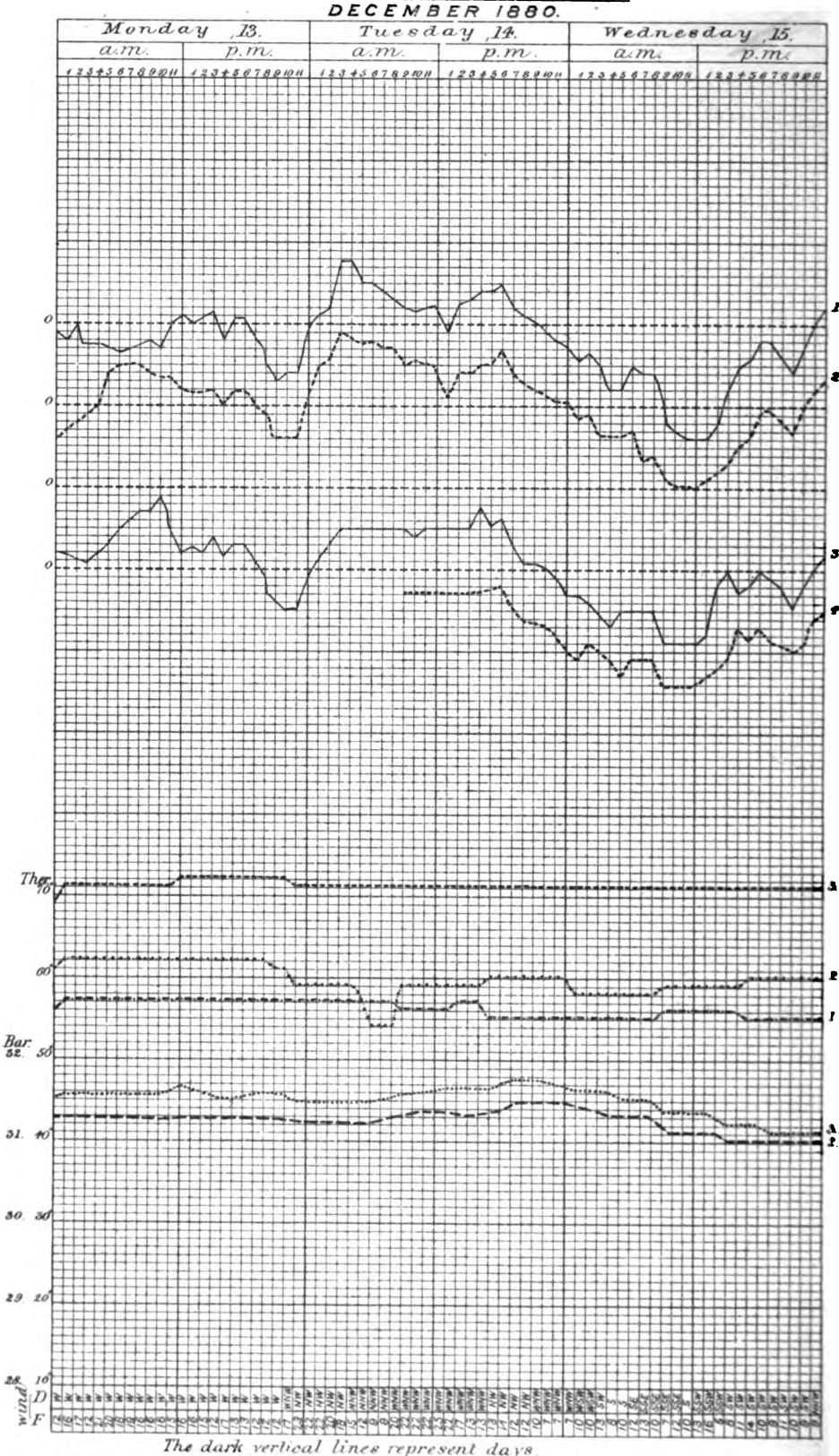
To illustrate Mr. Corbetts paper.



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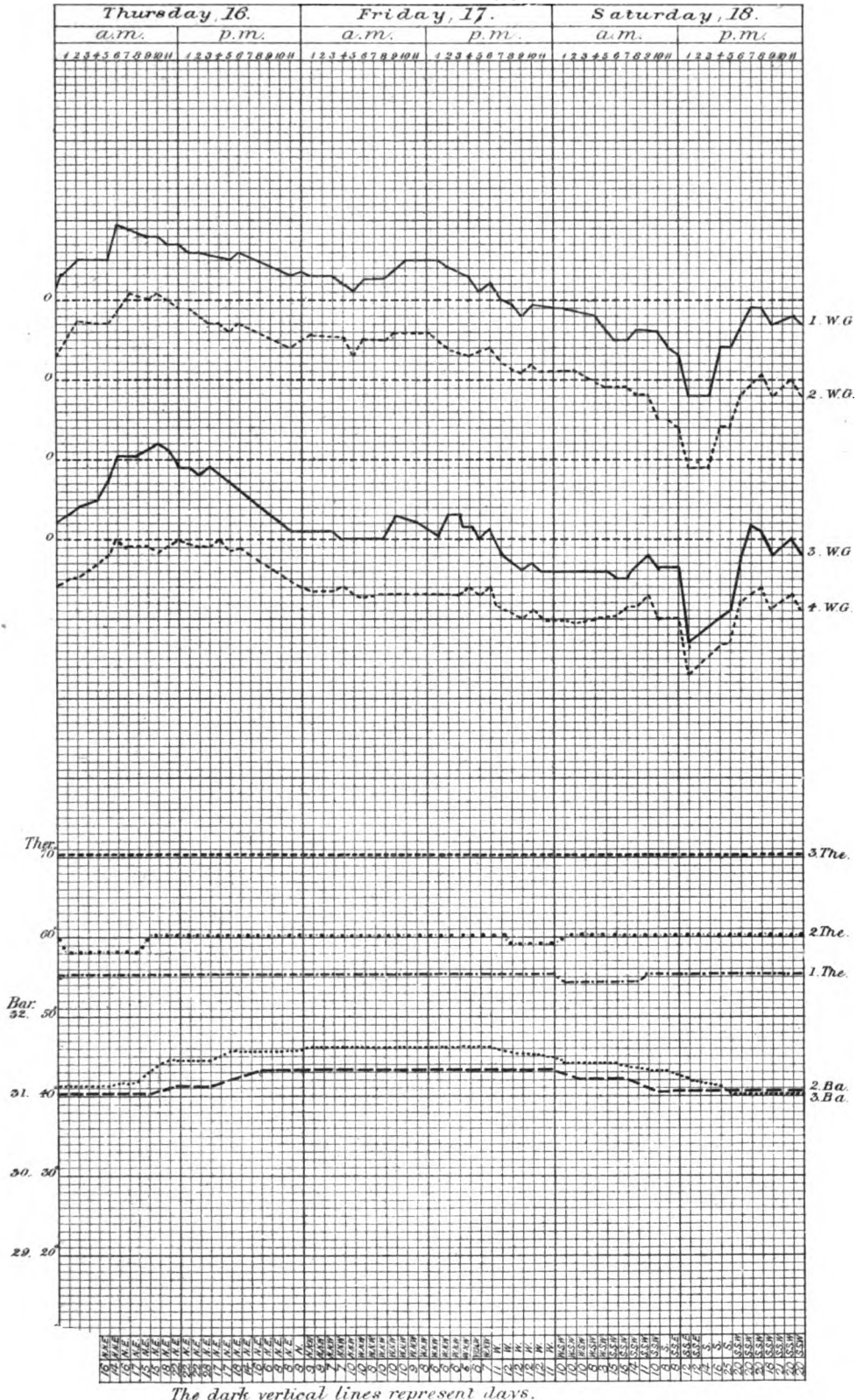

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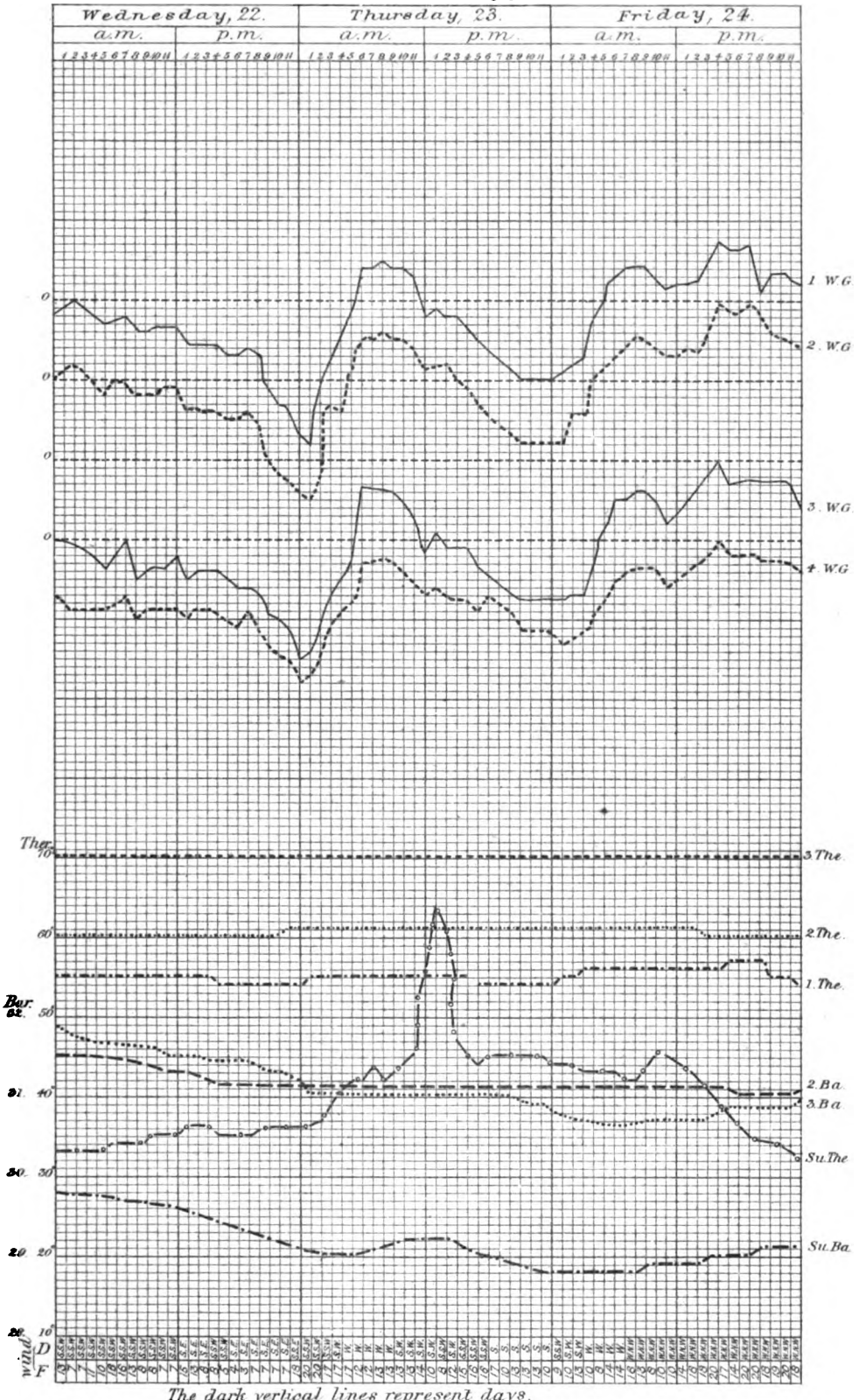

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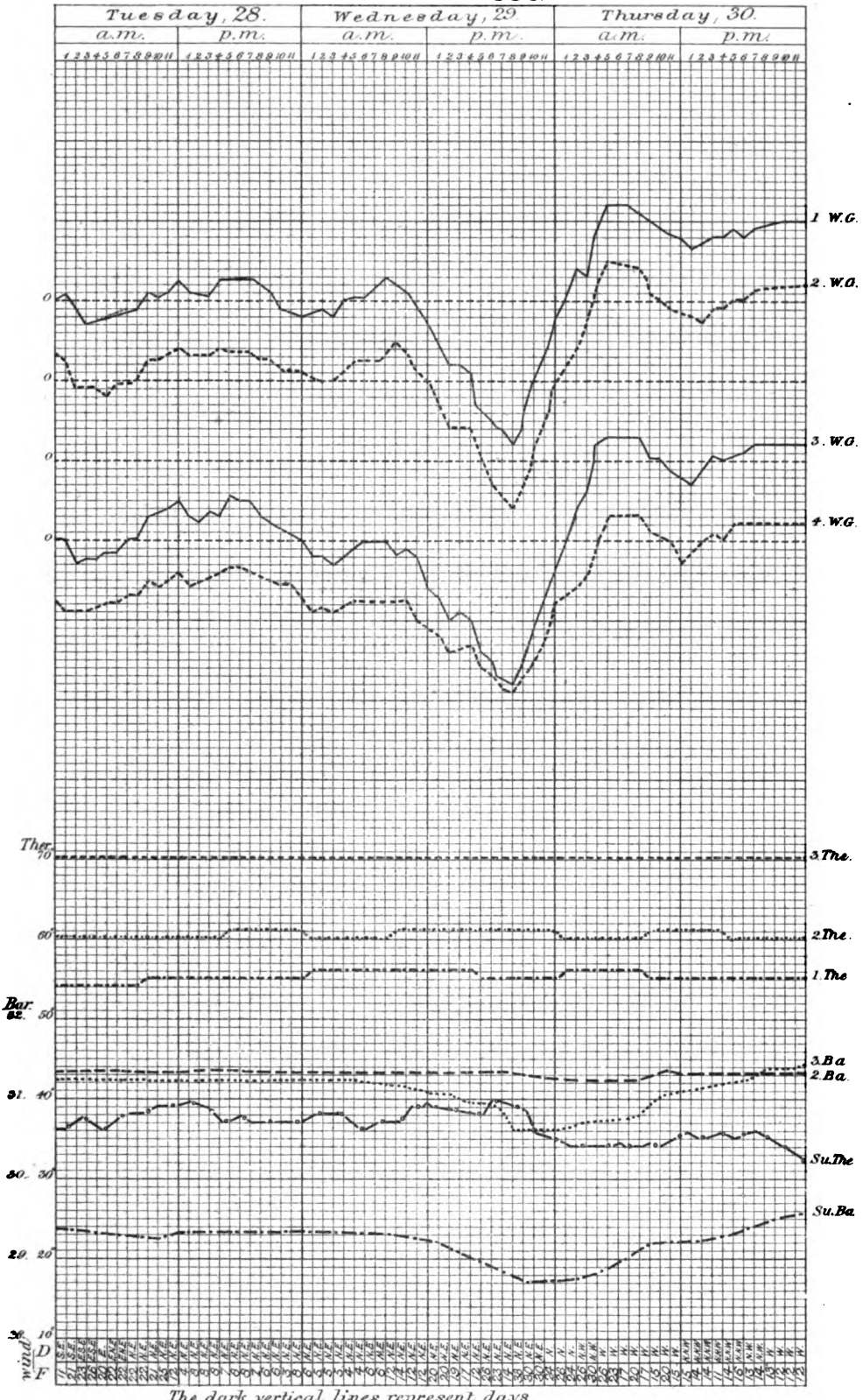

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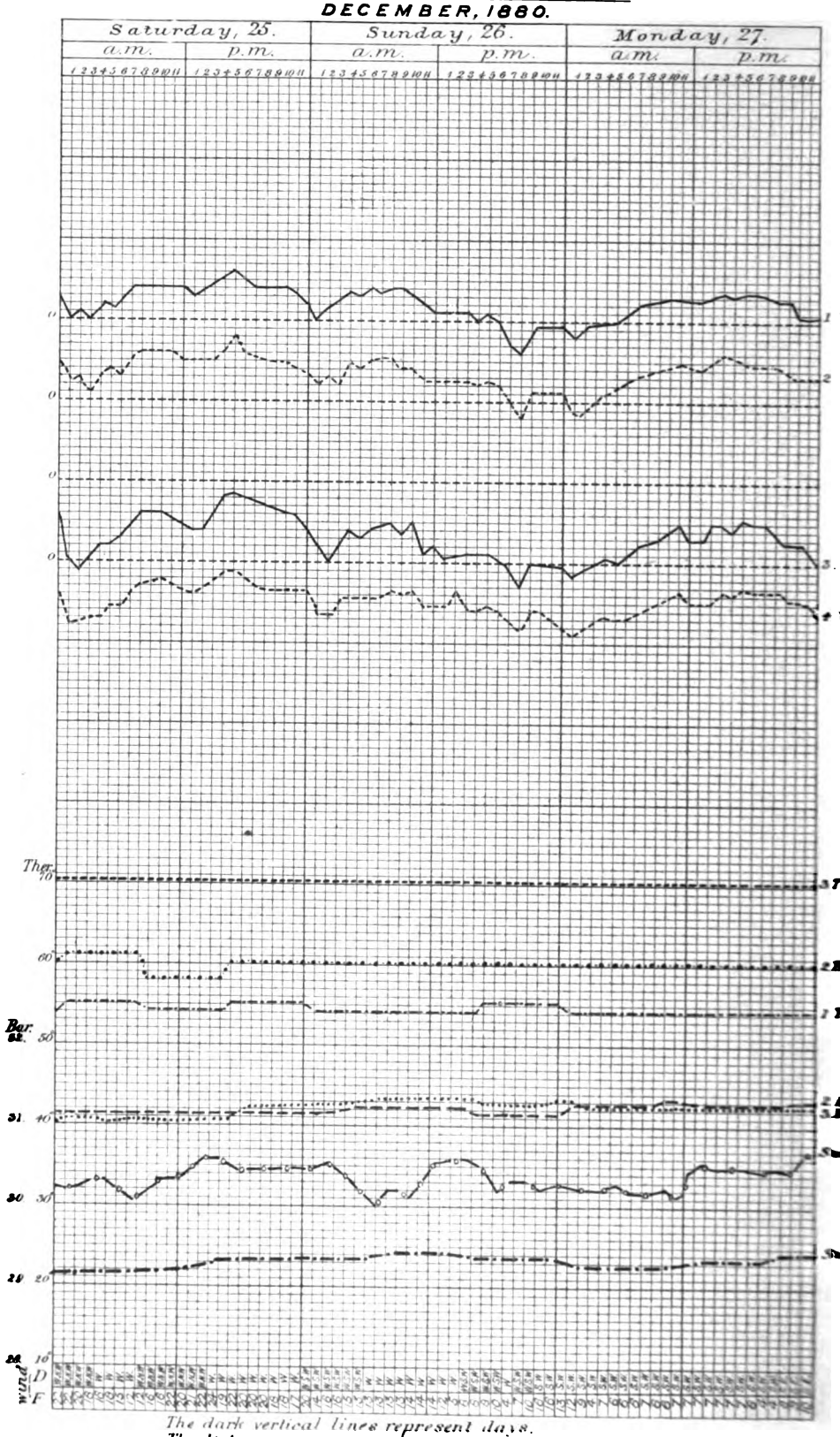

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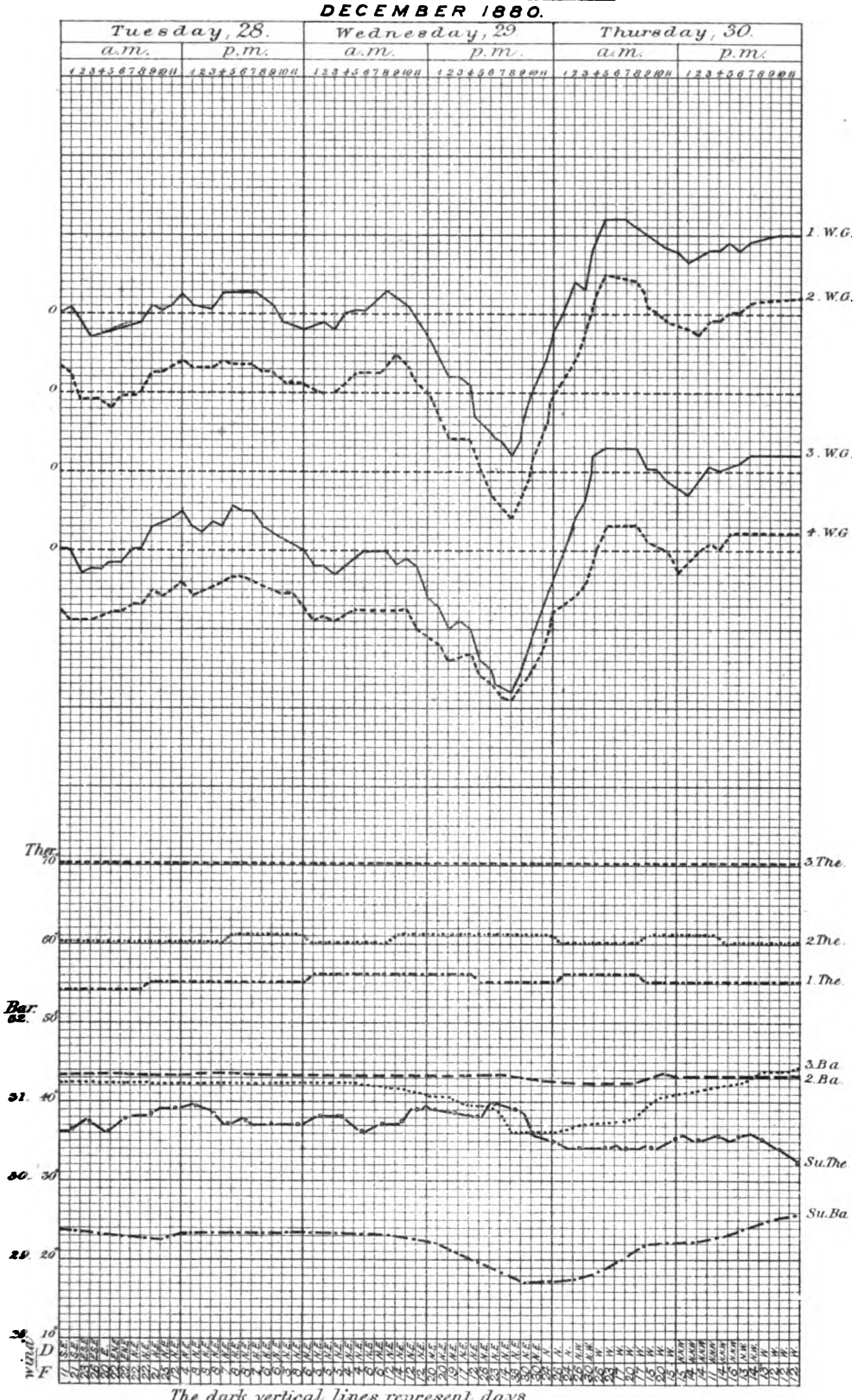

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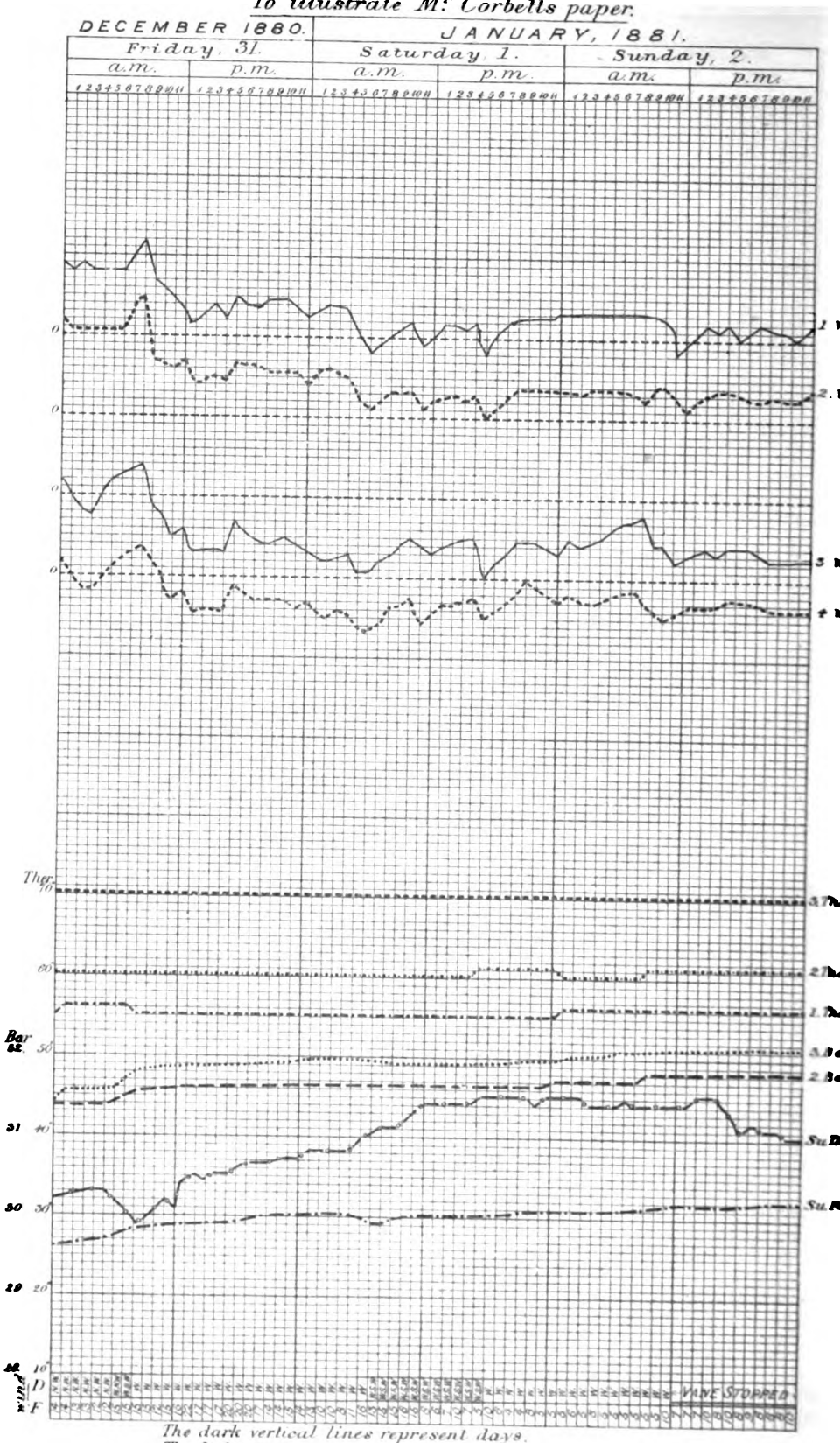

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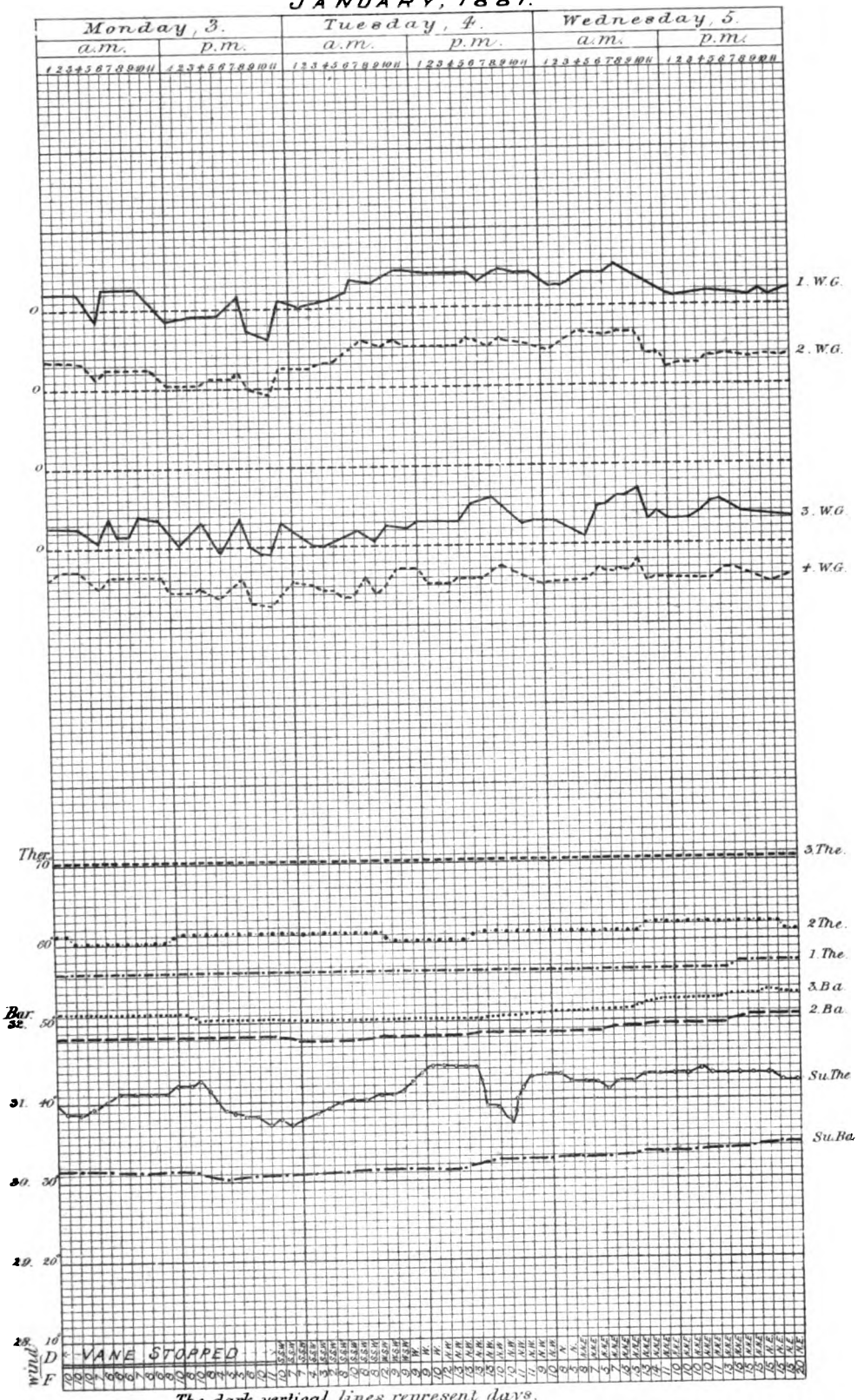

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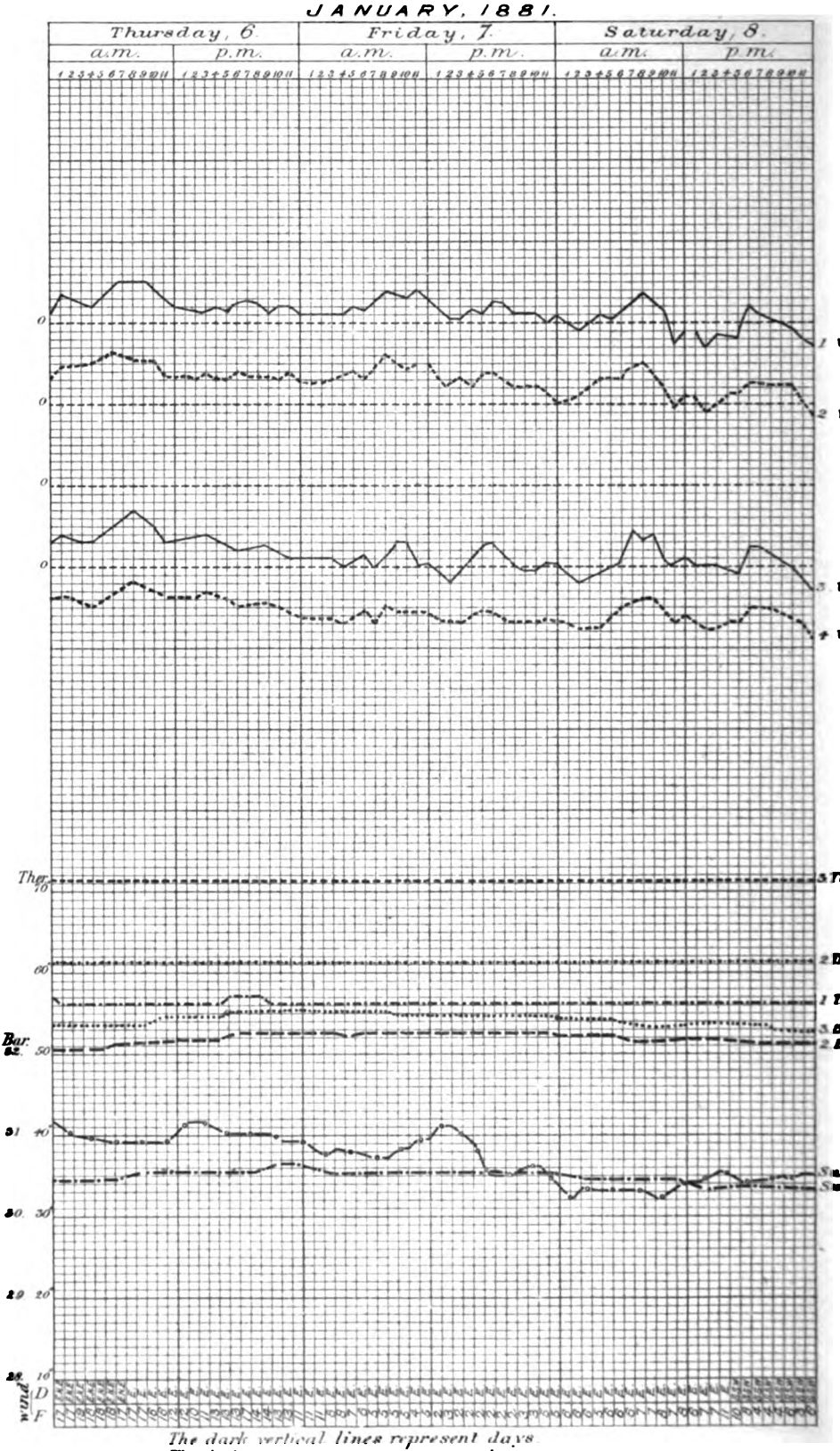

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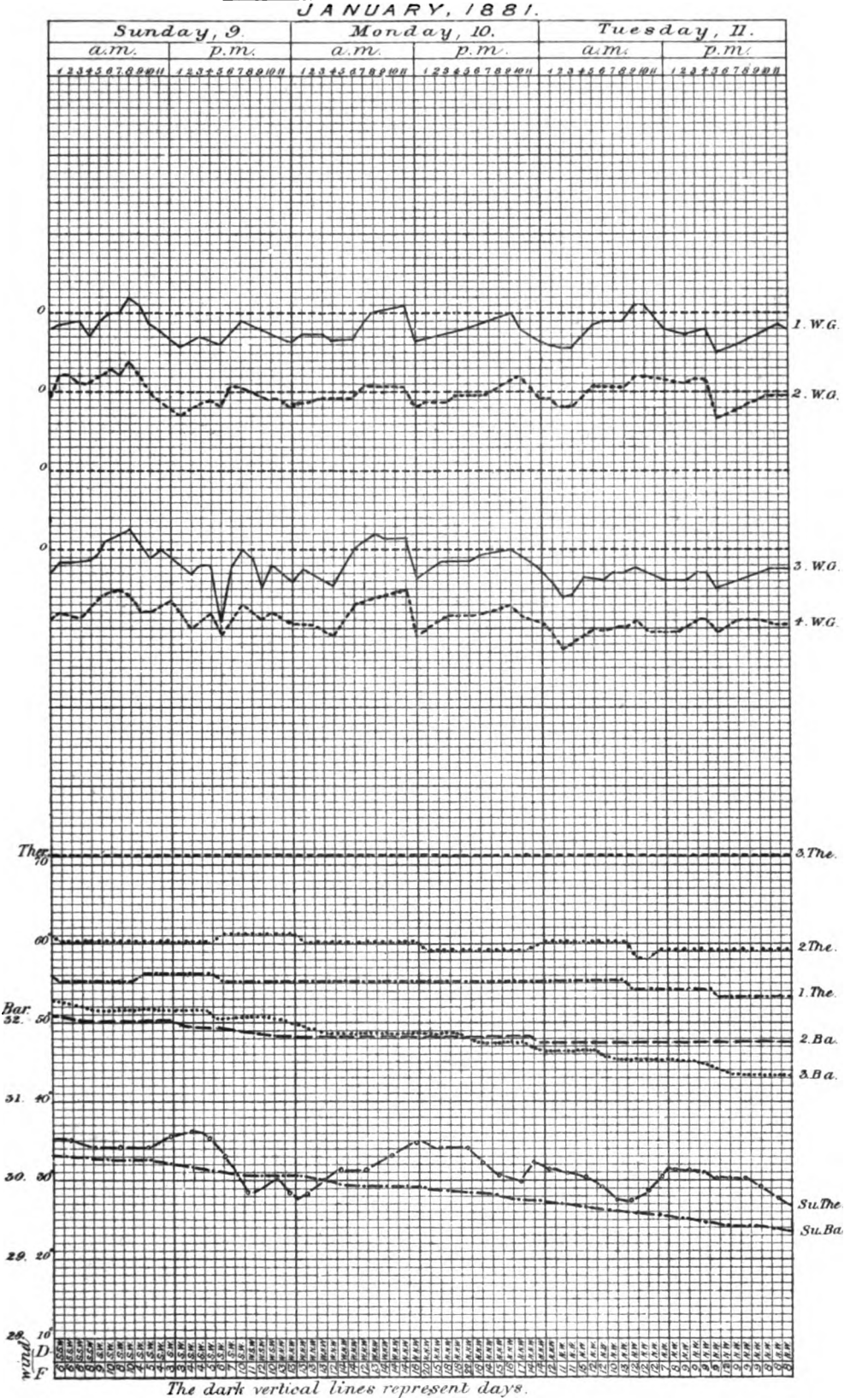

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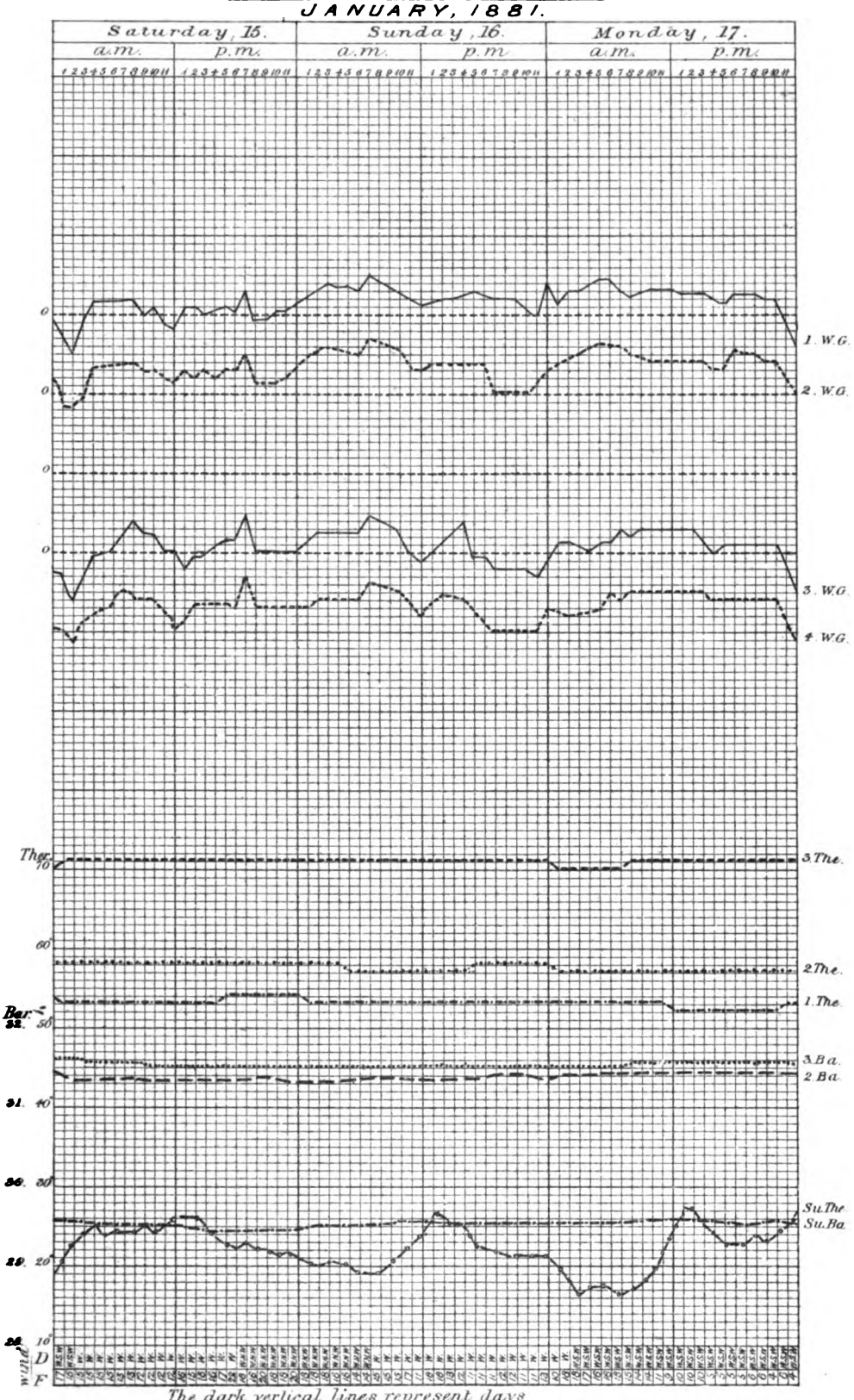

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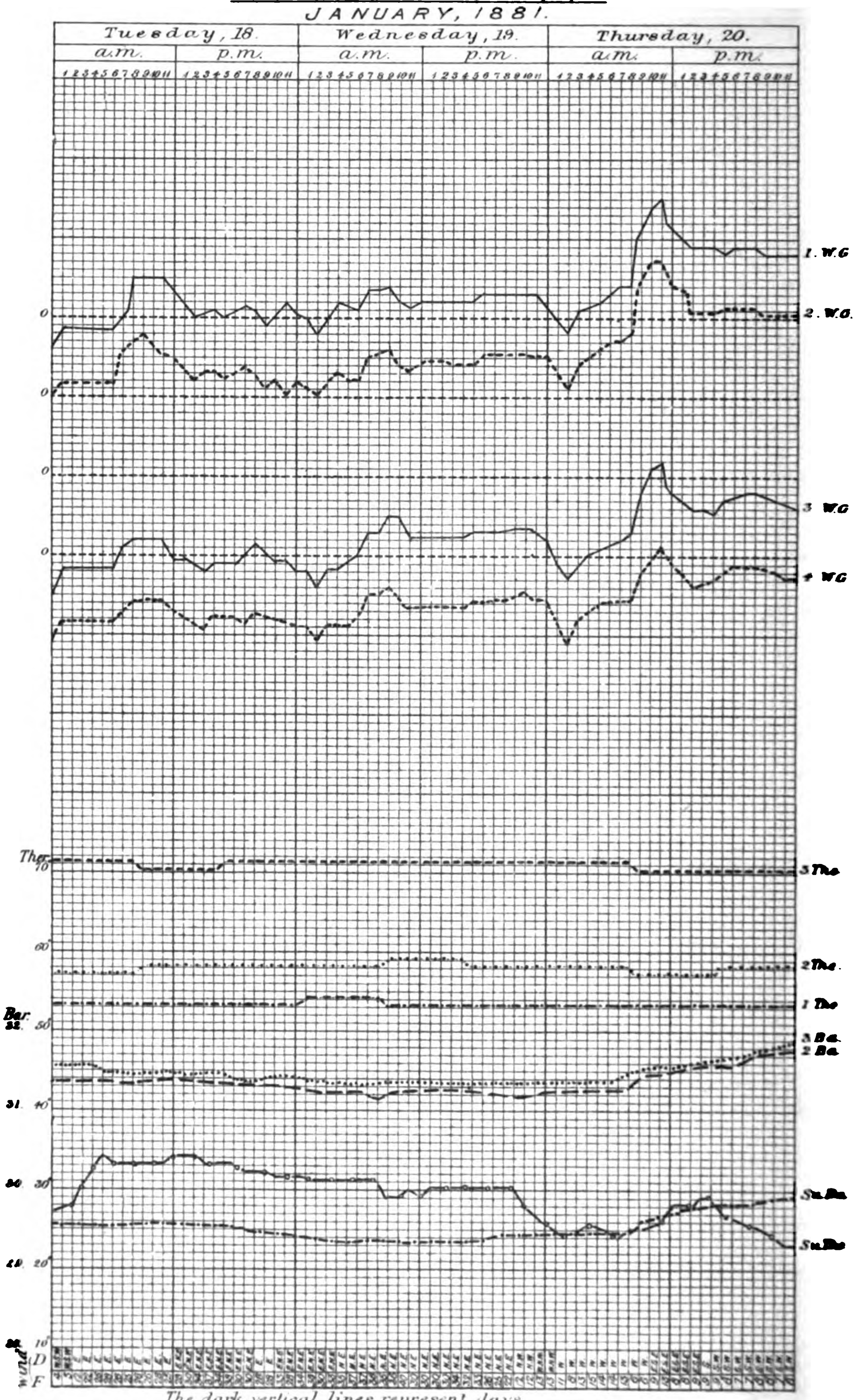

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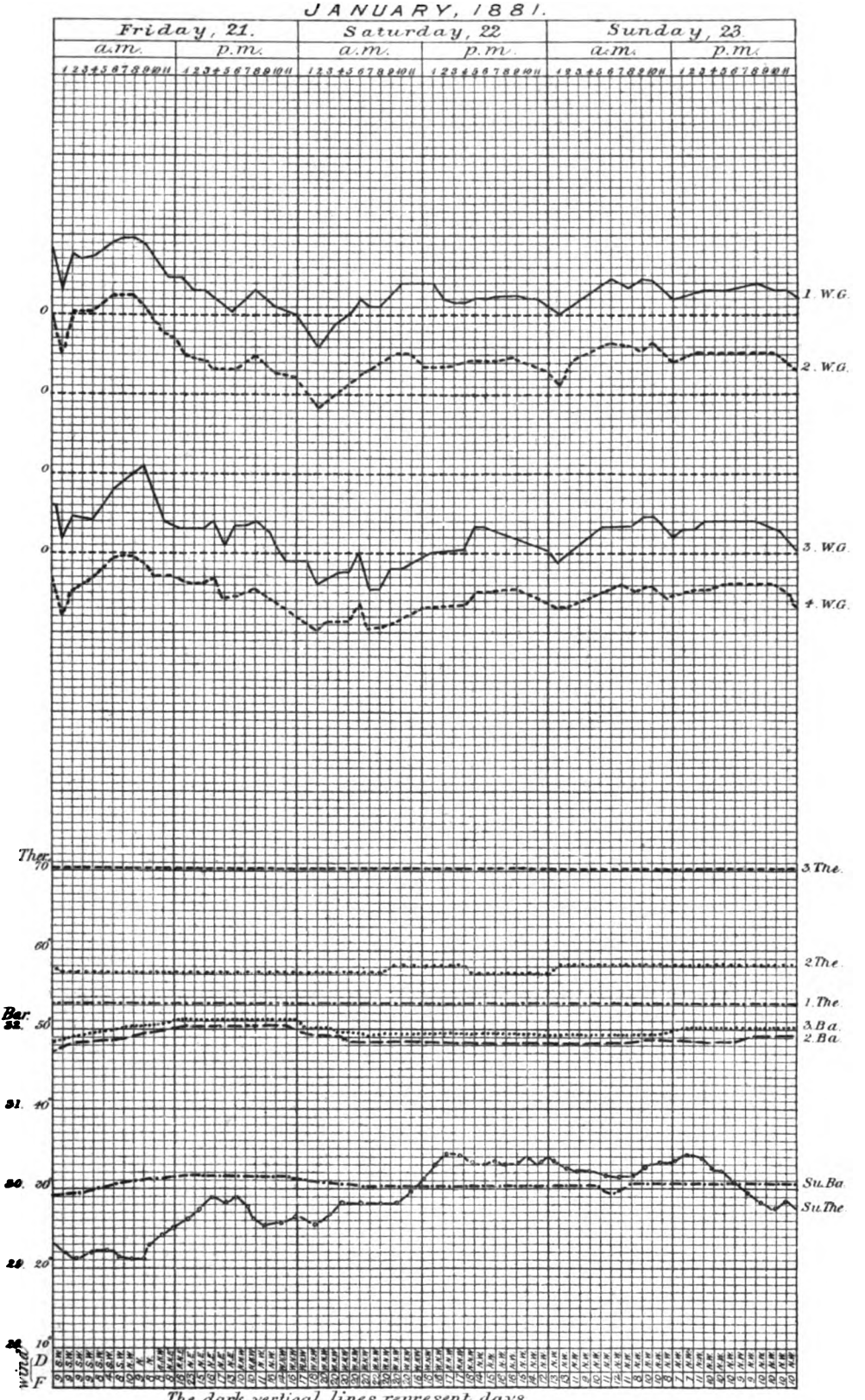

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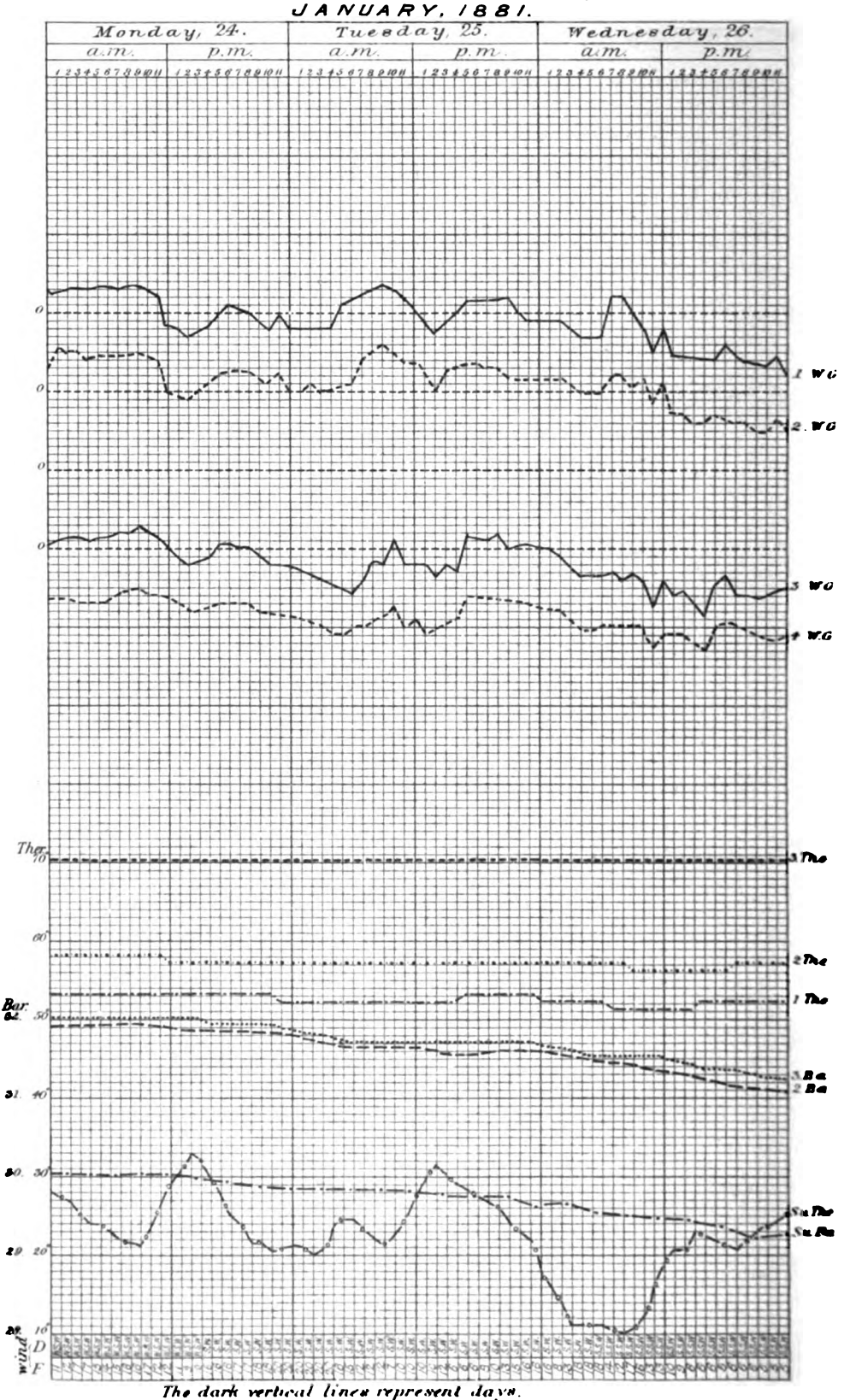

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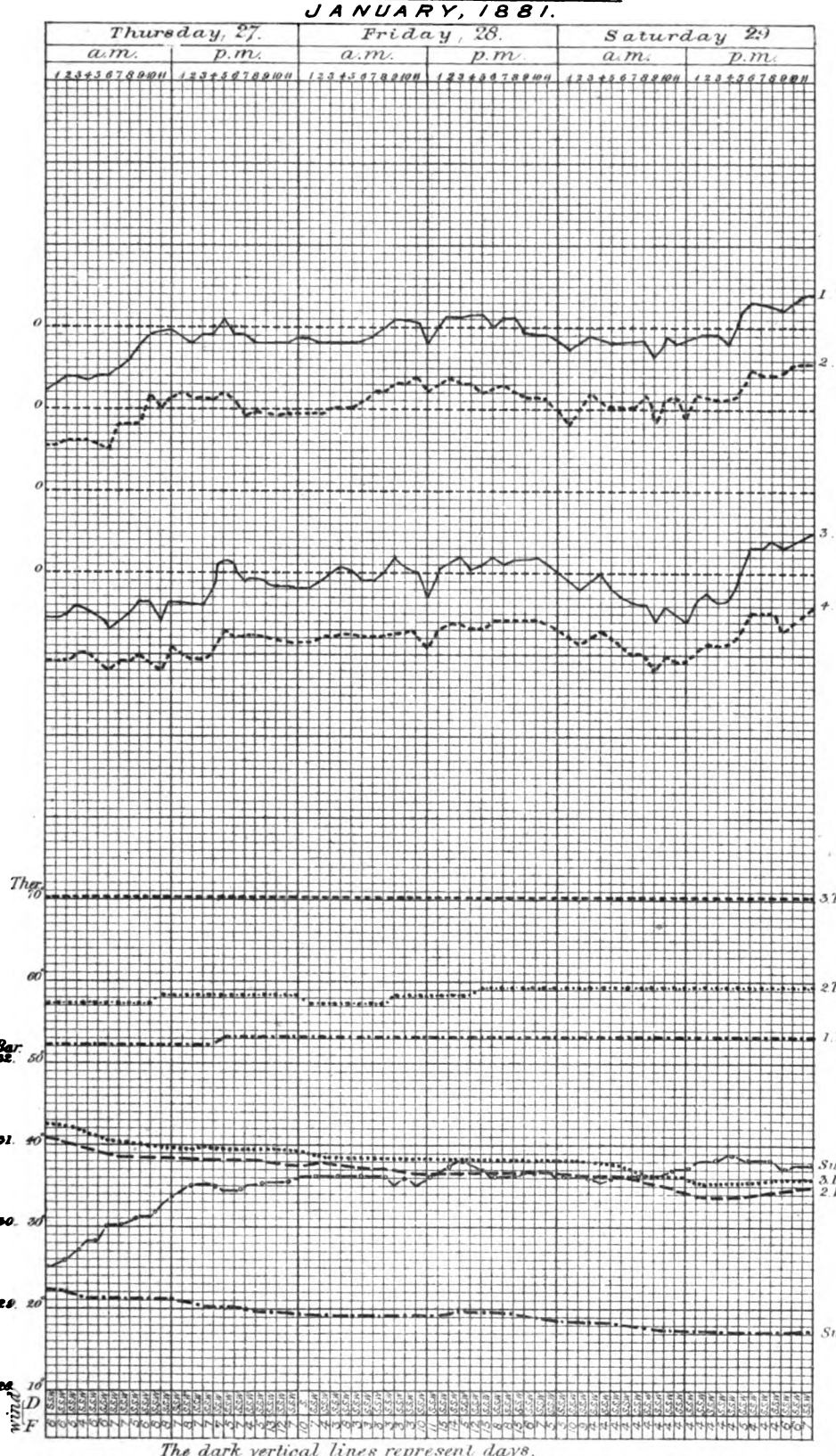

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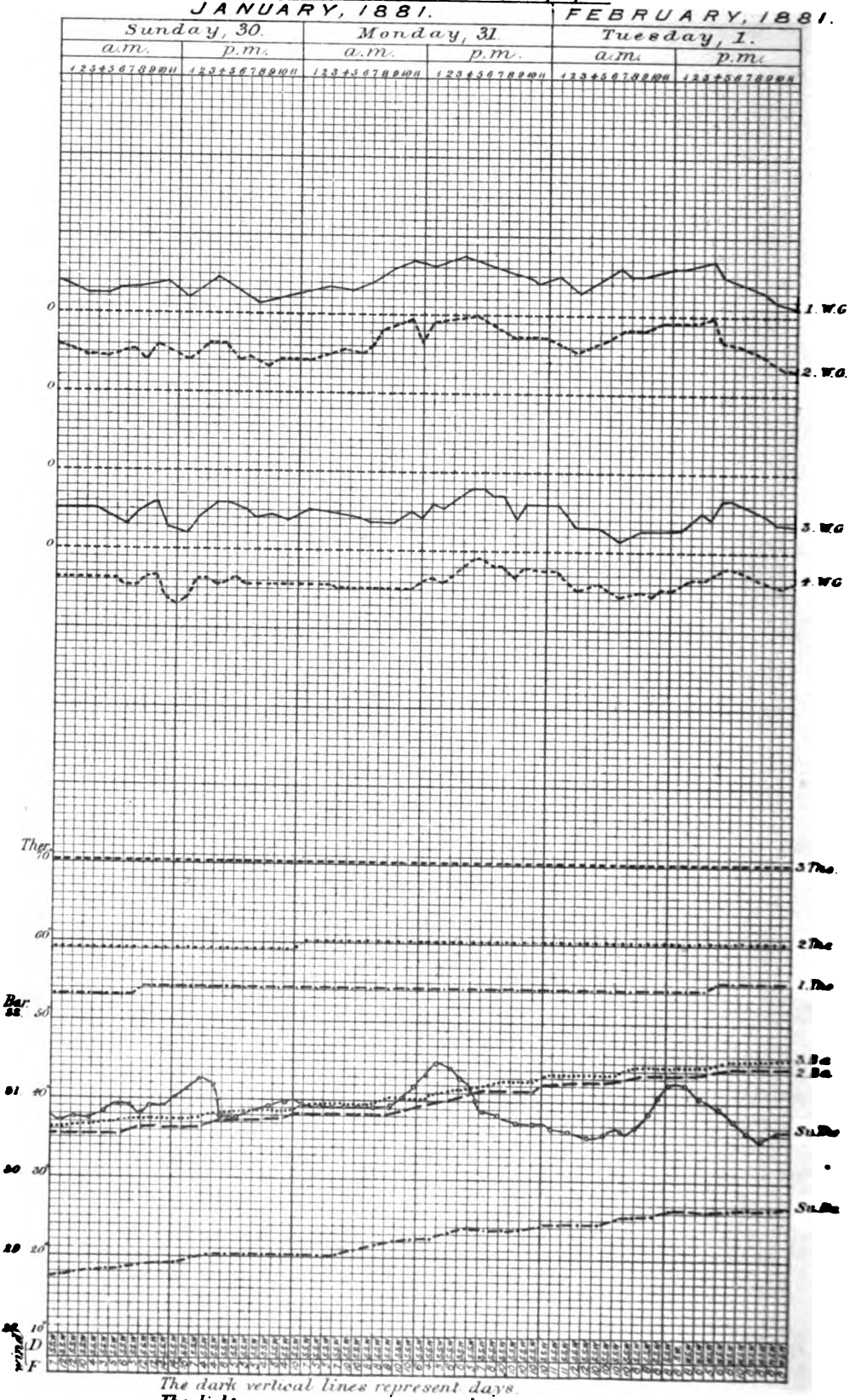

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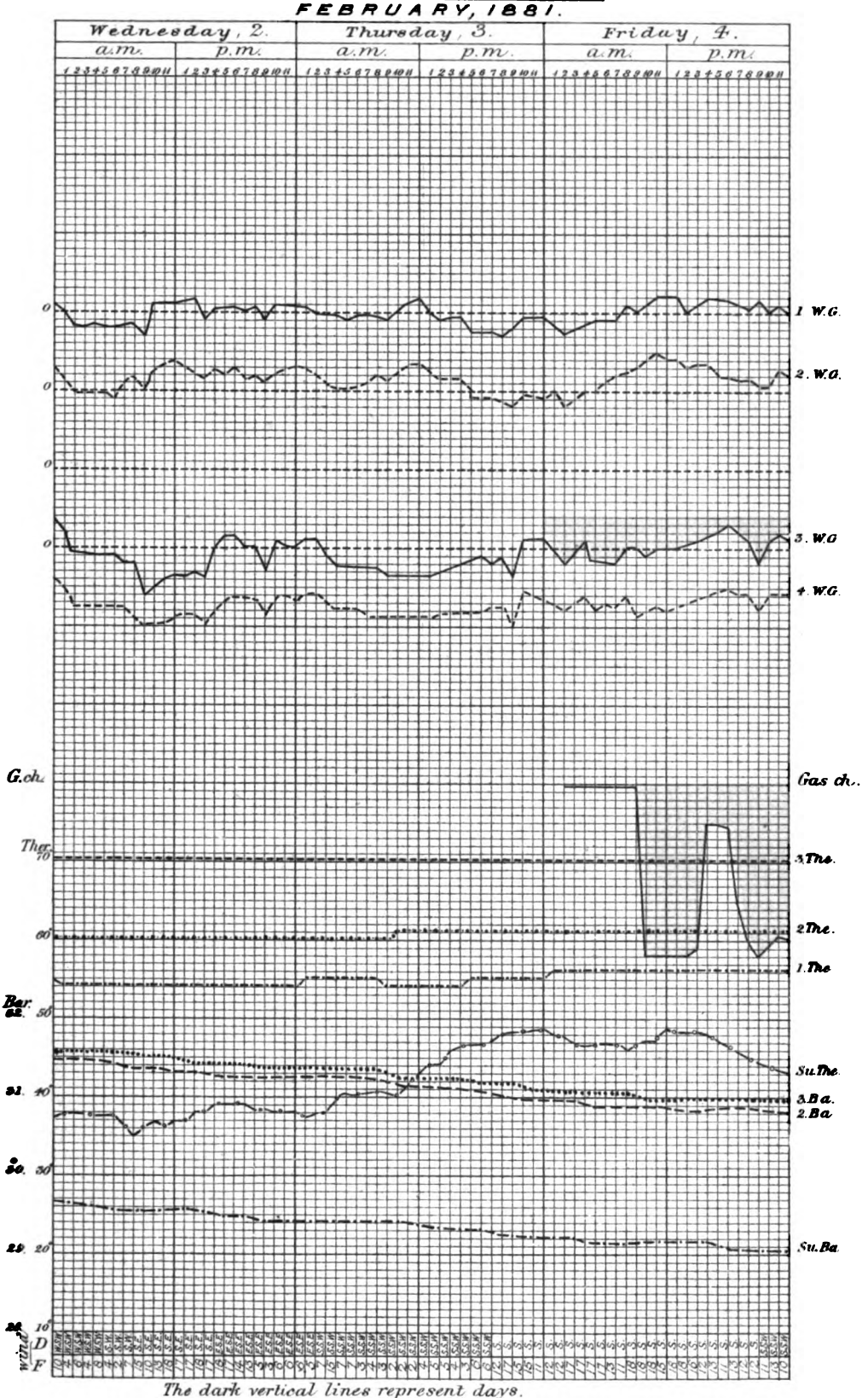

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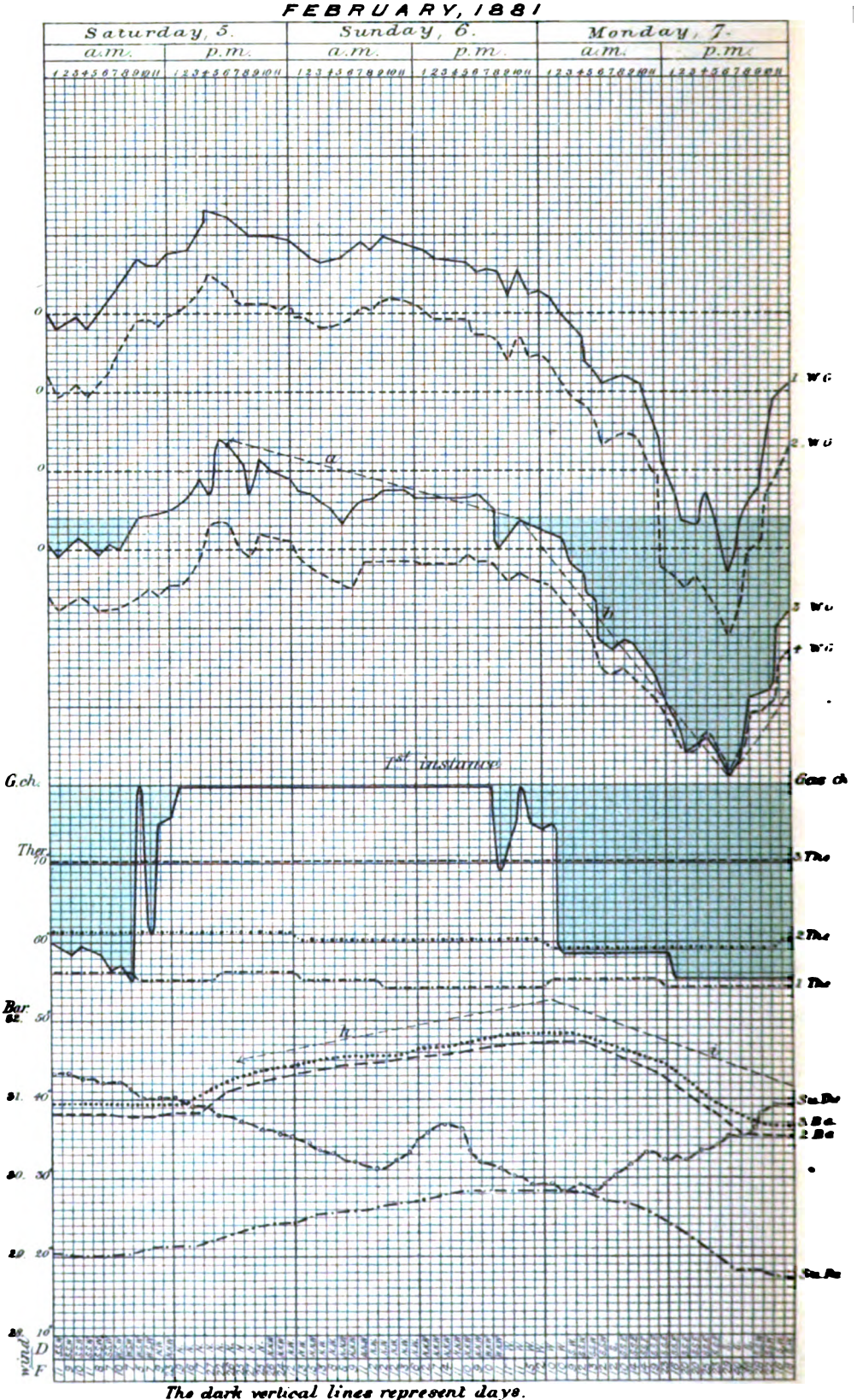

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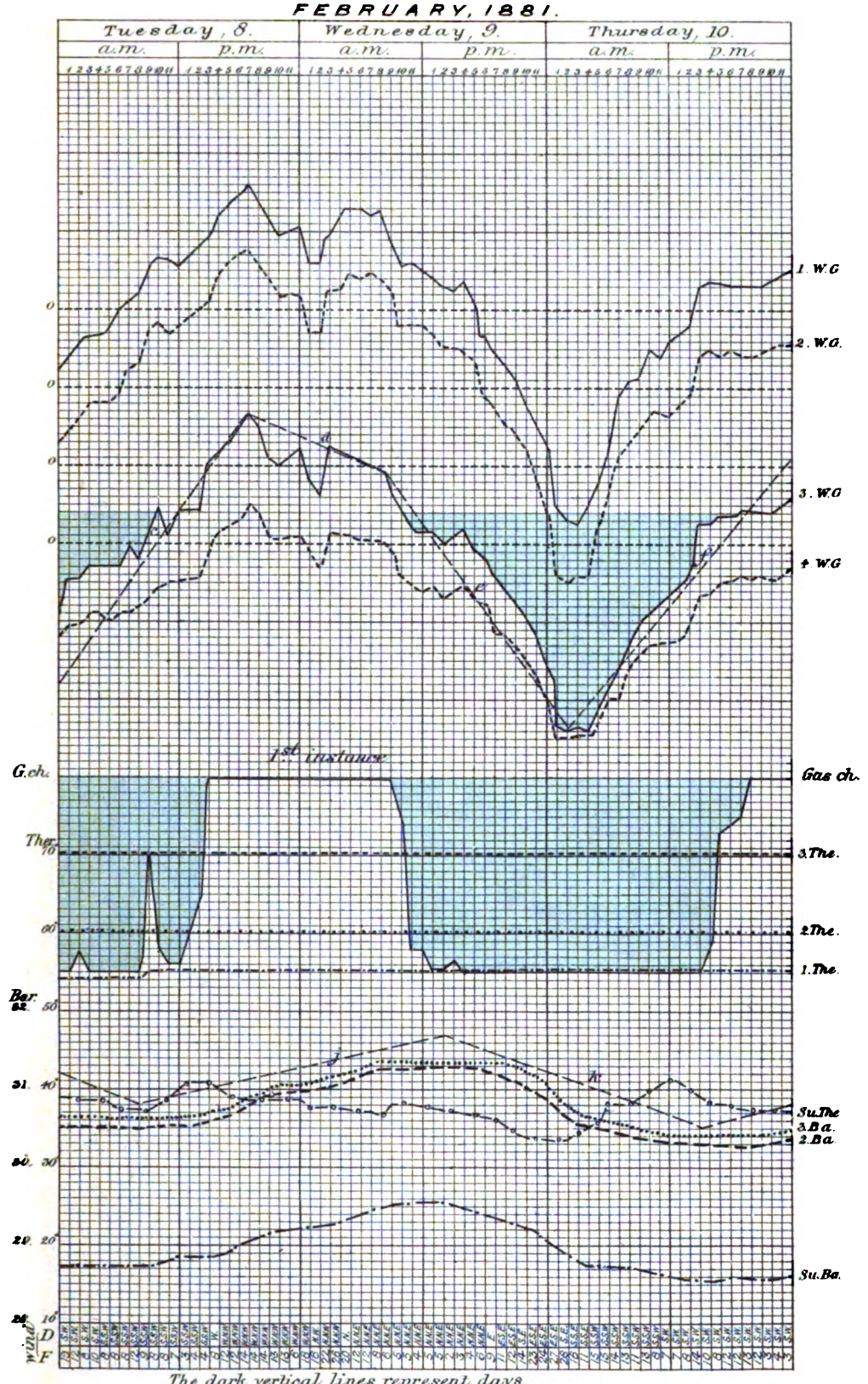

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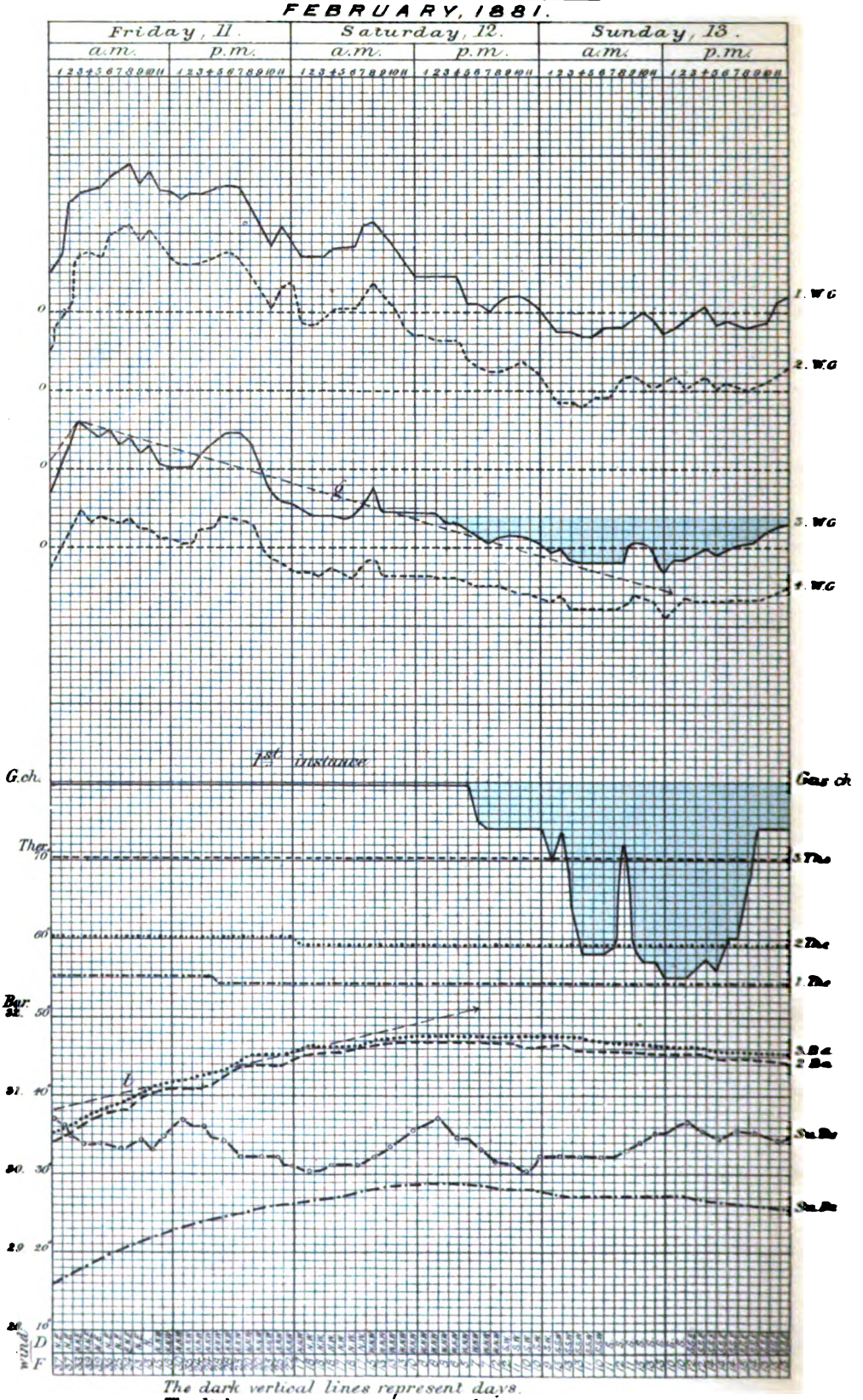

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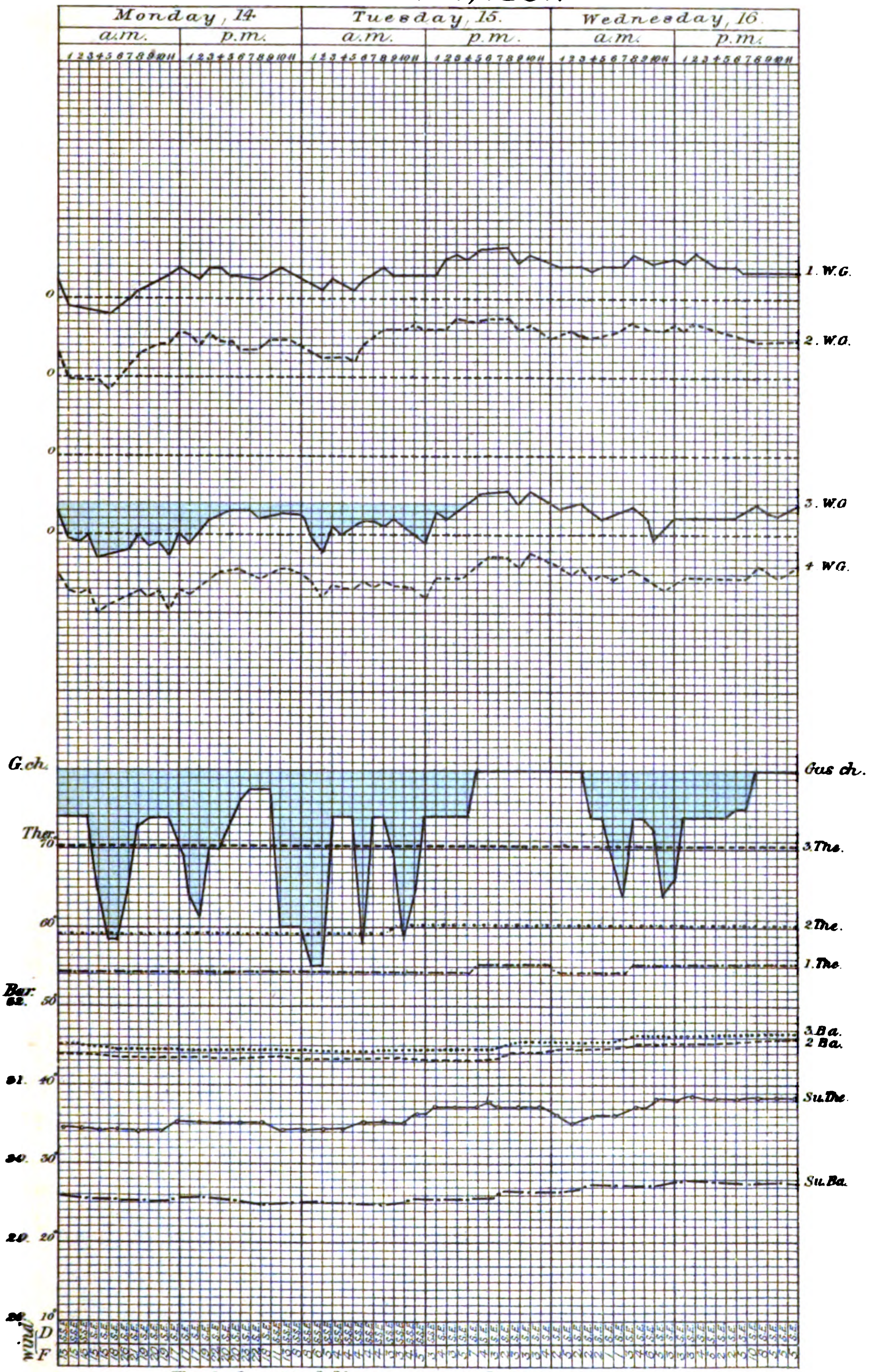

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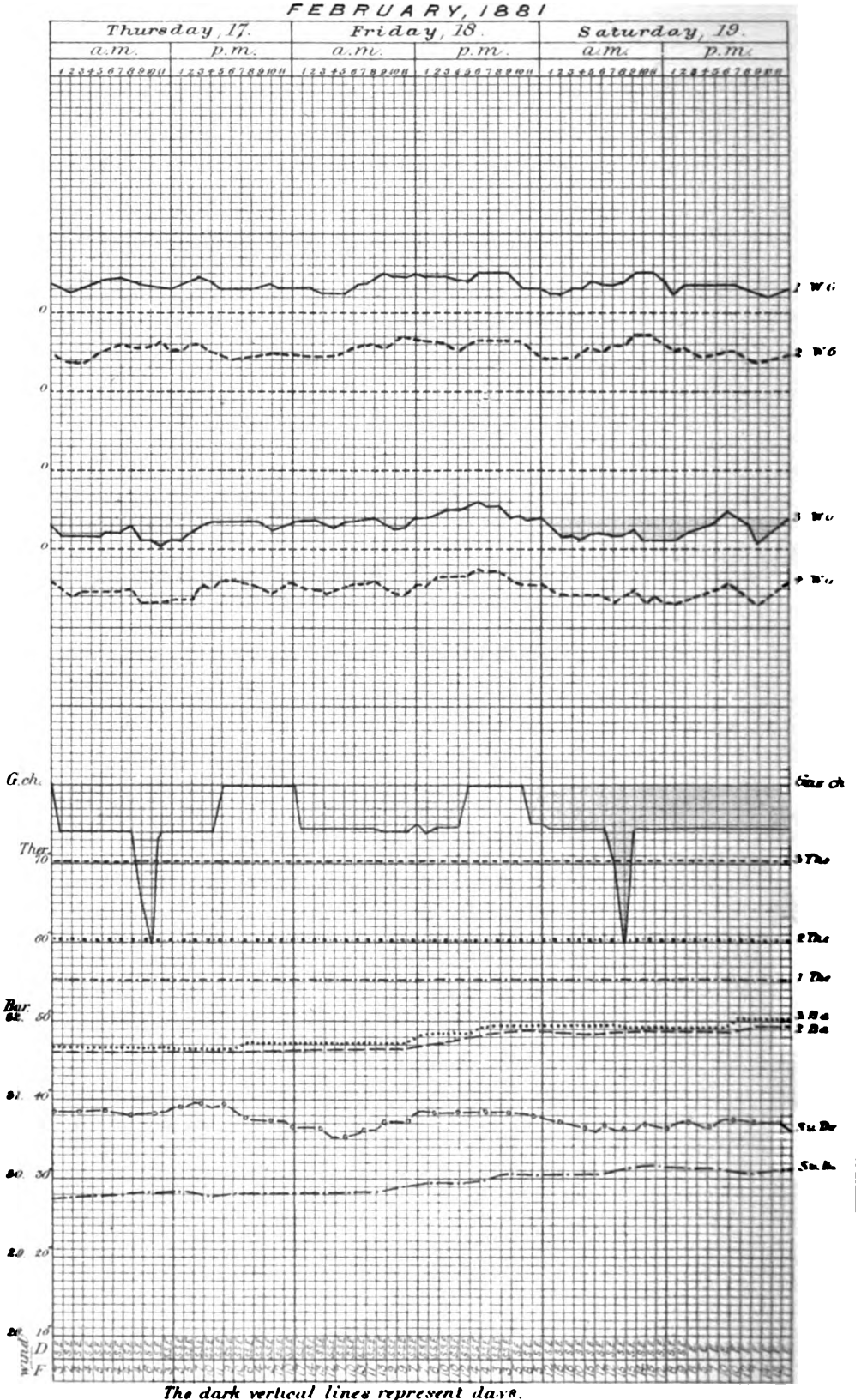

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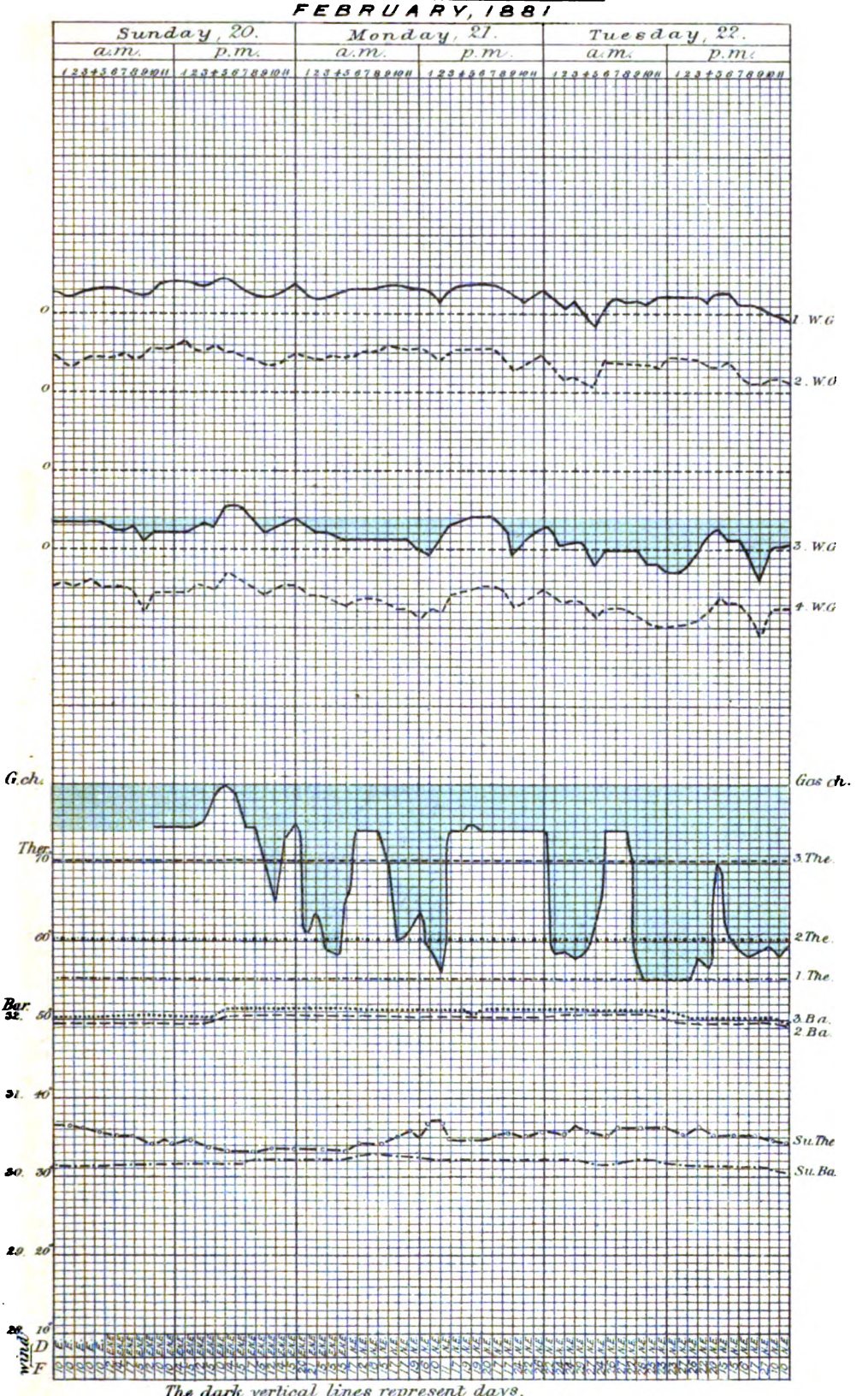

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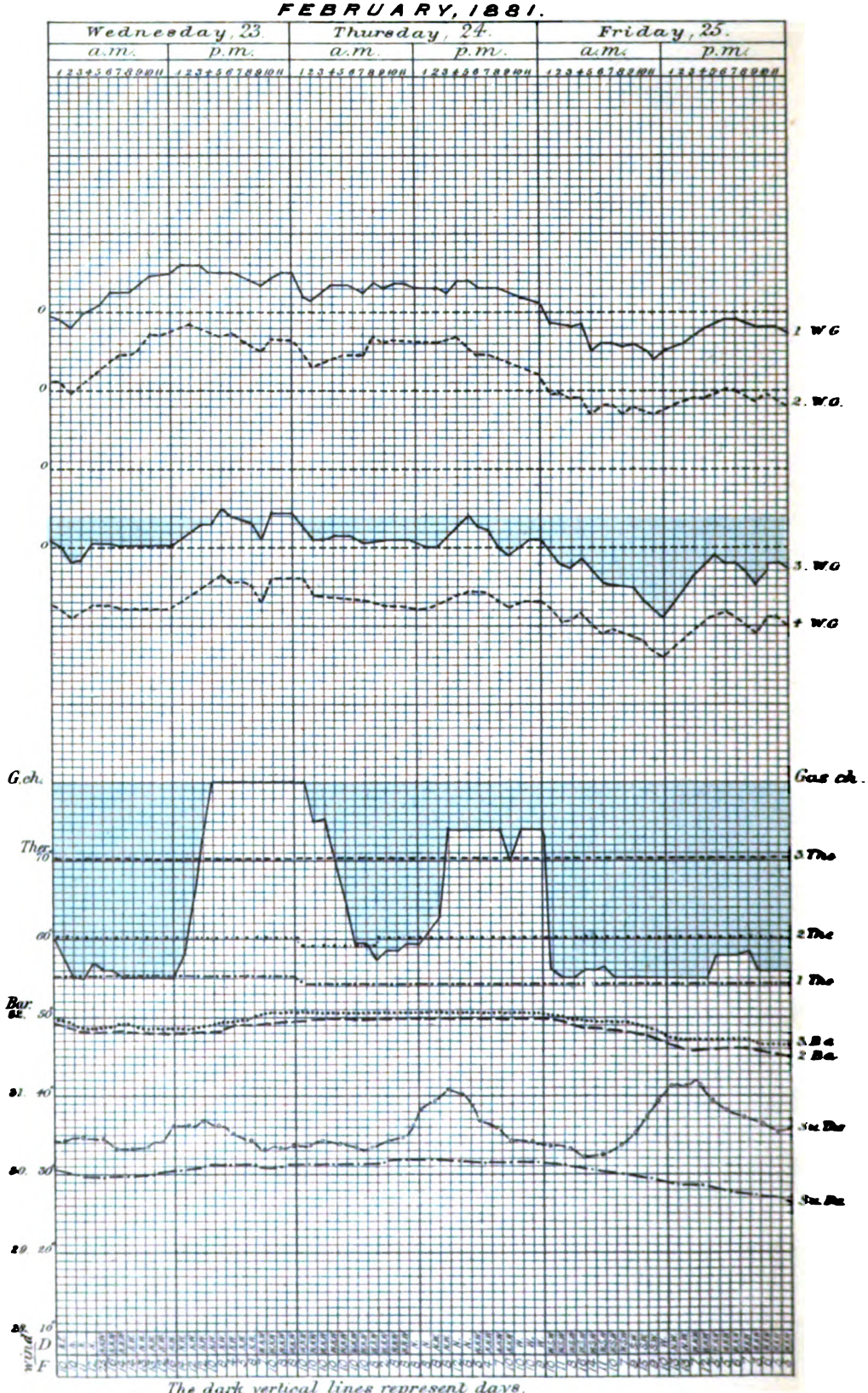

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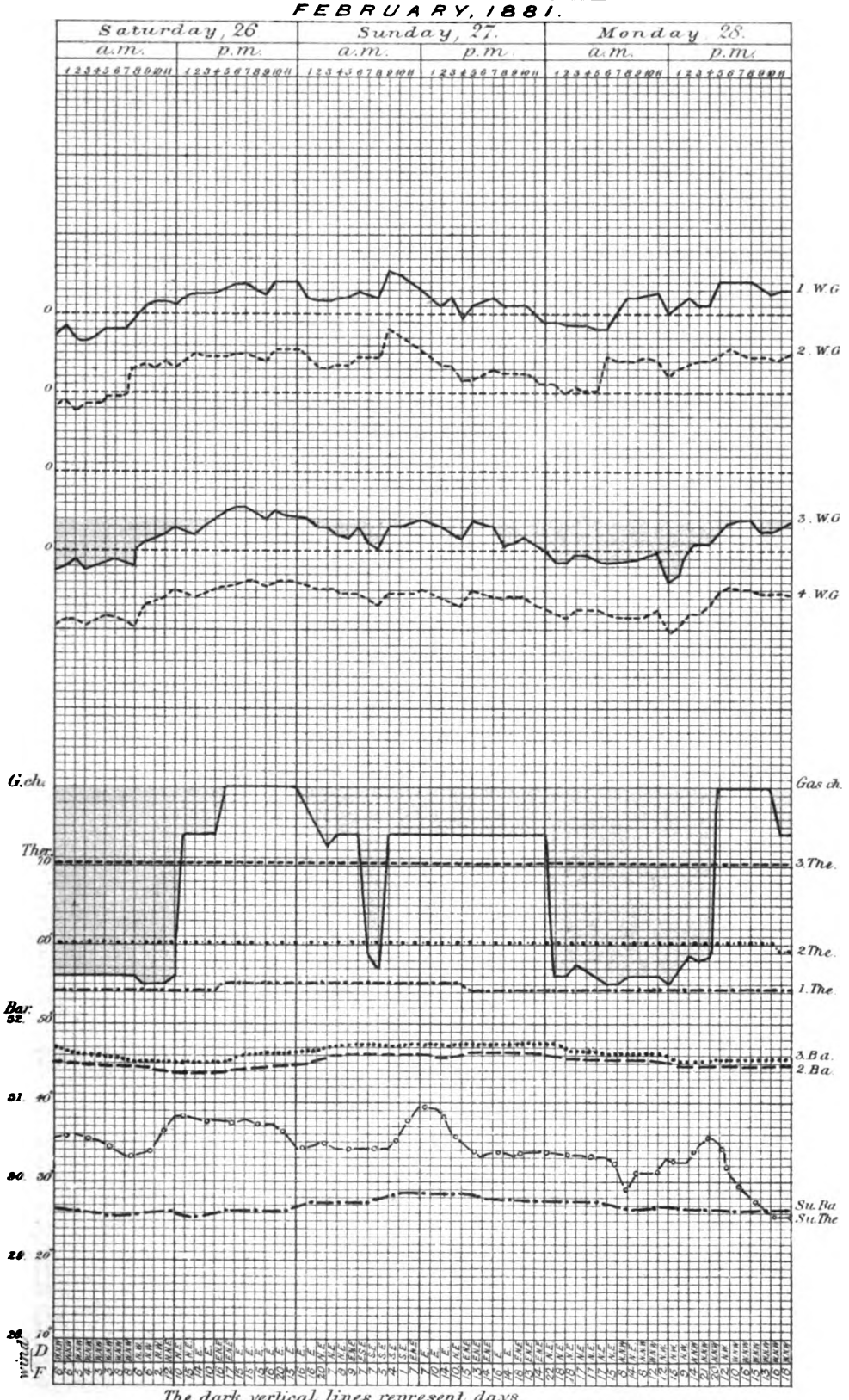

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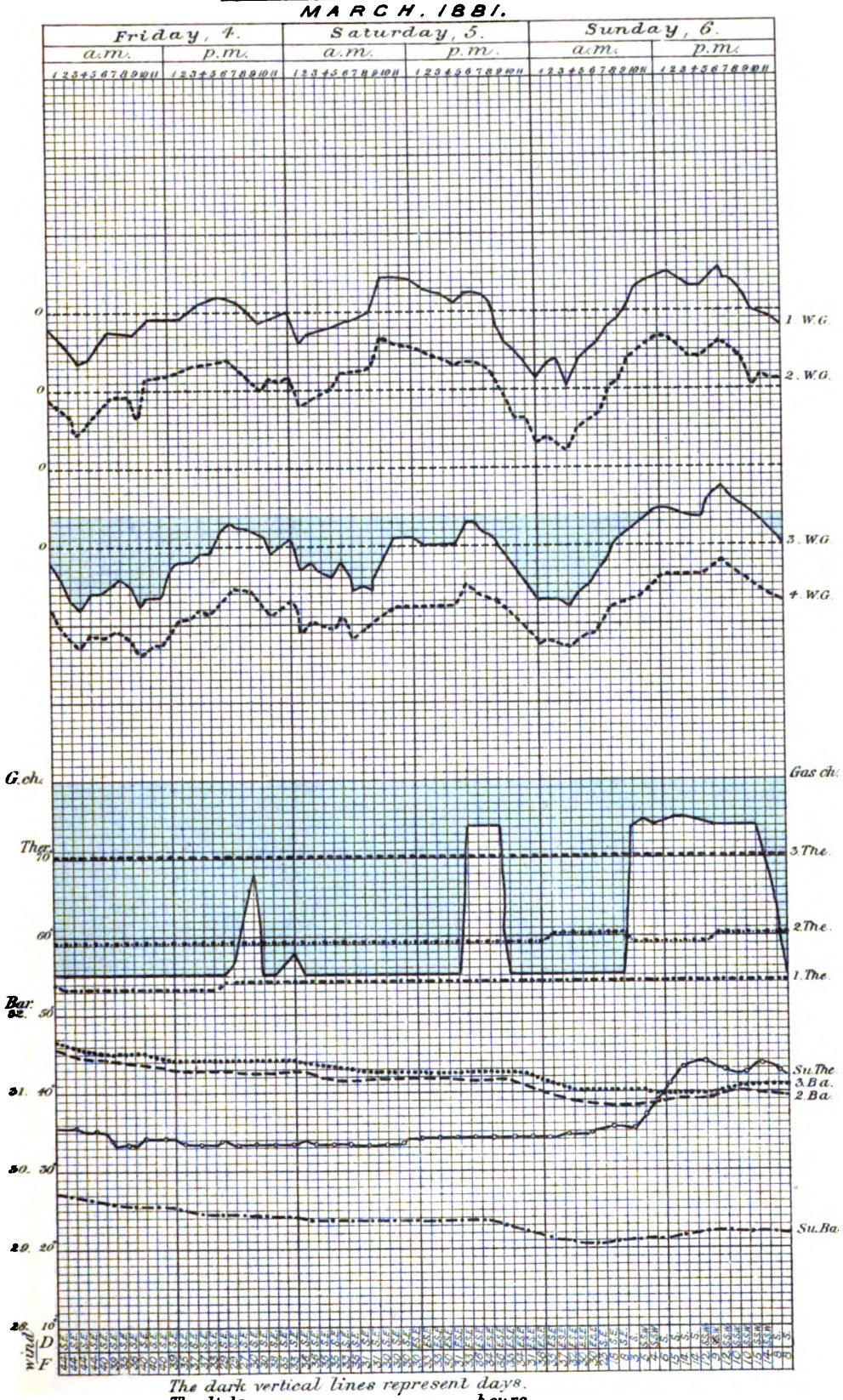

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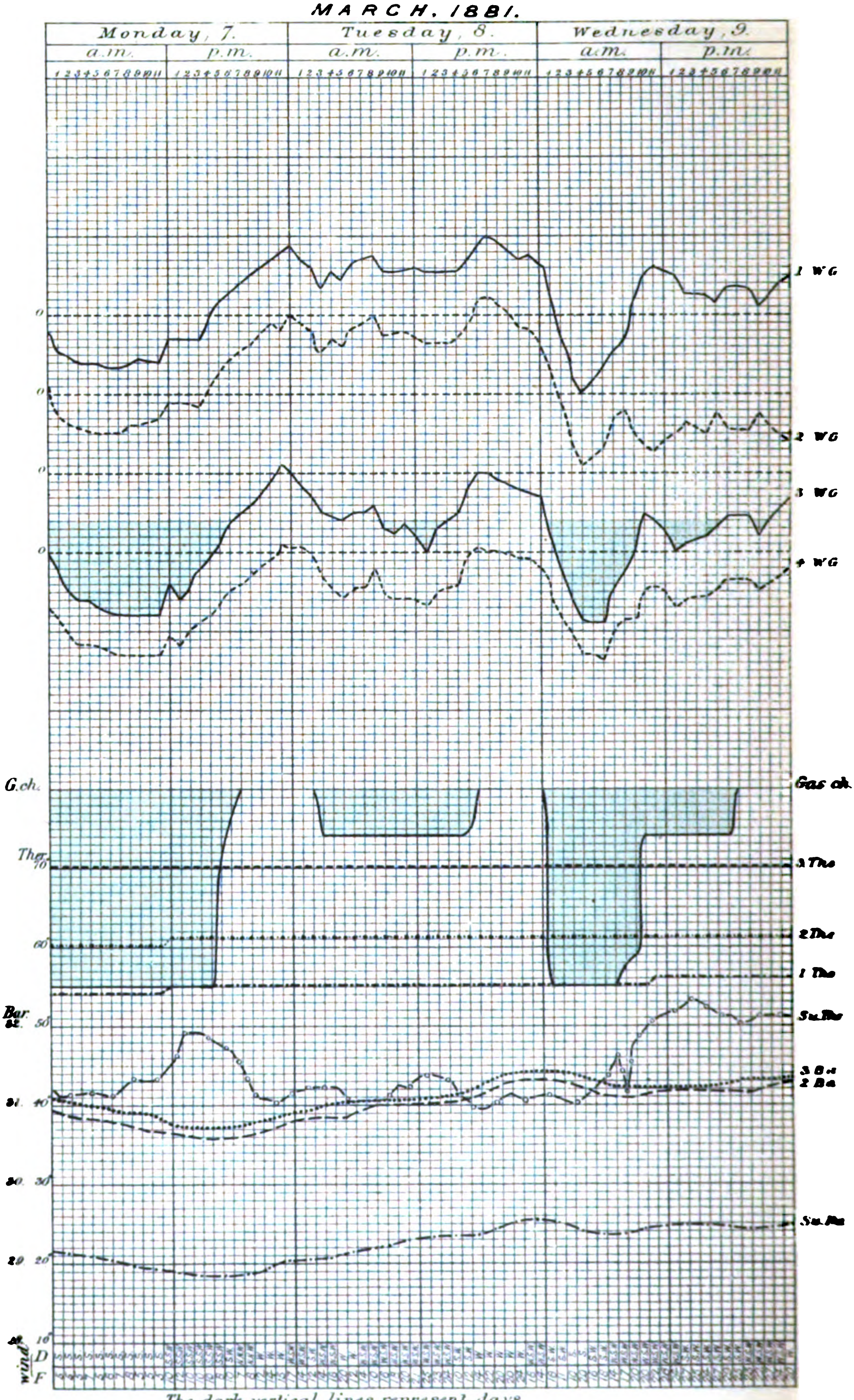

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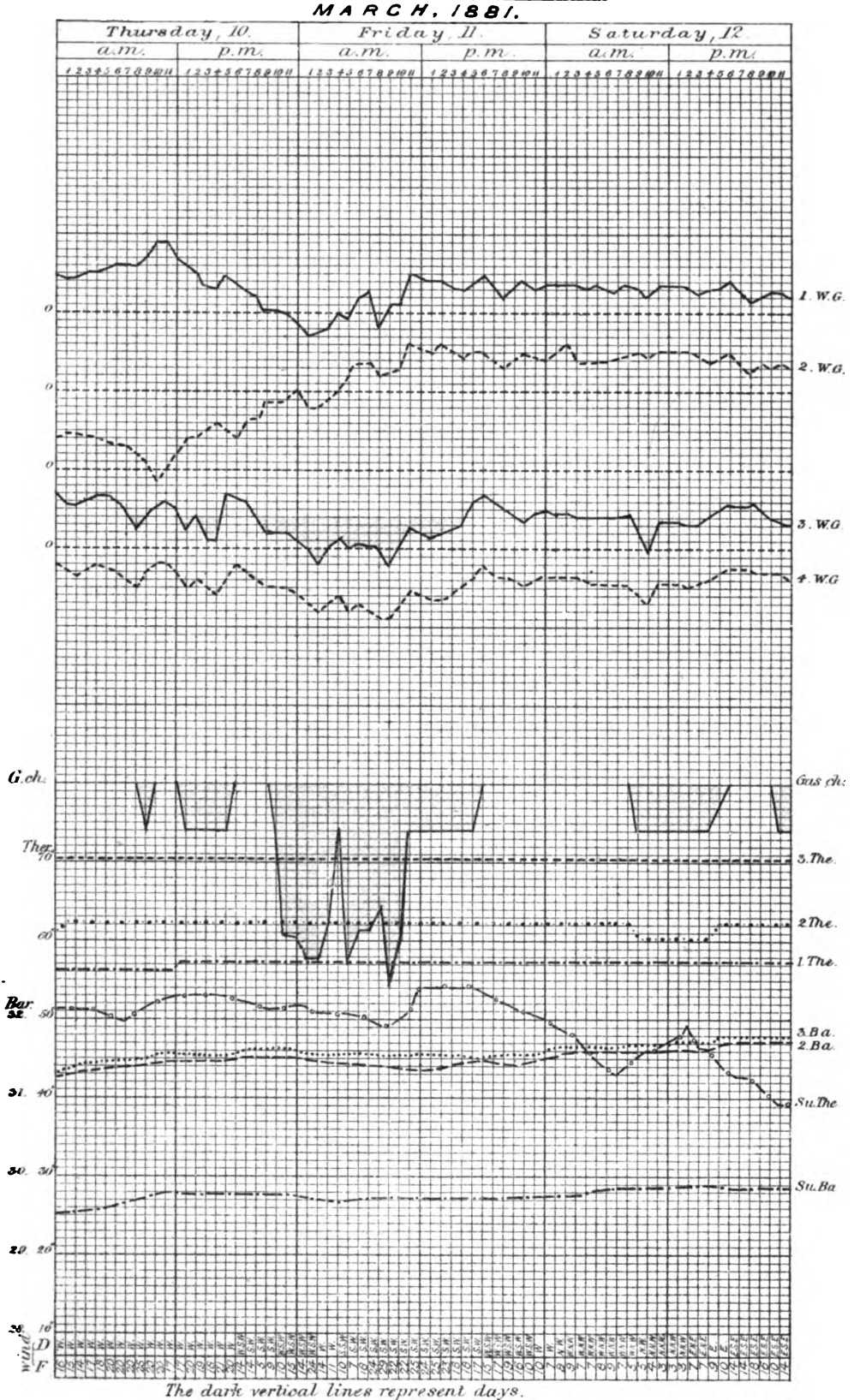

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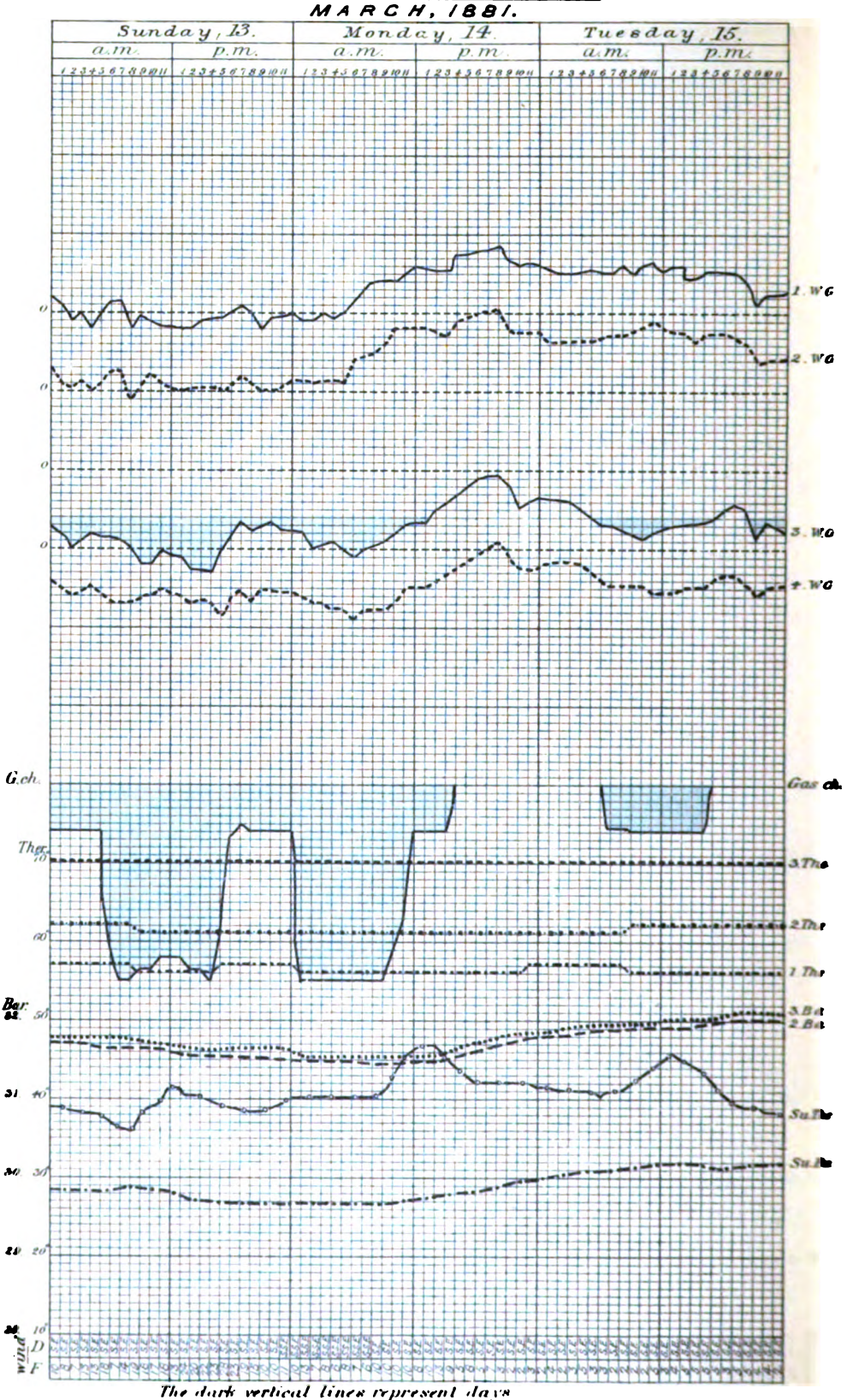

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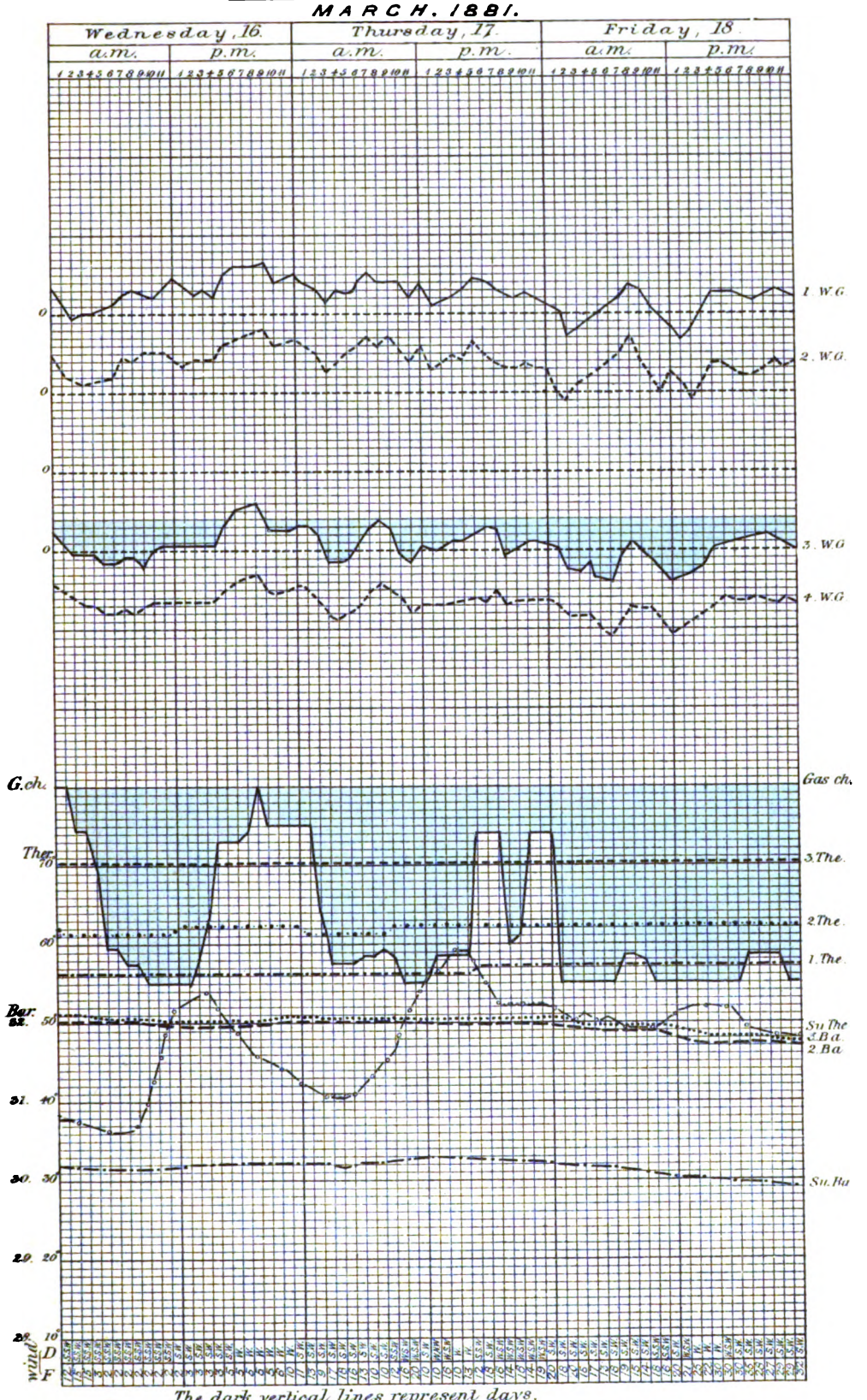

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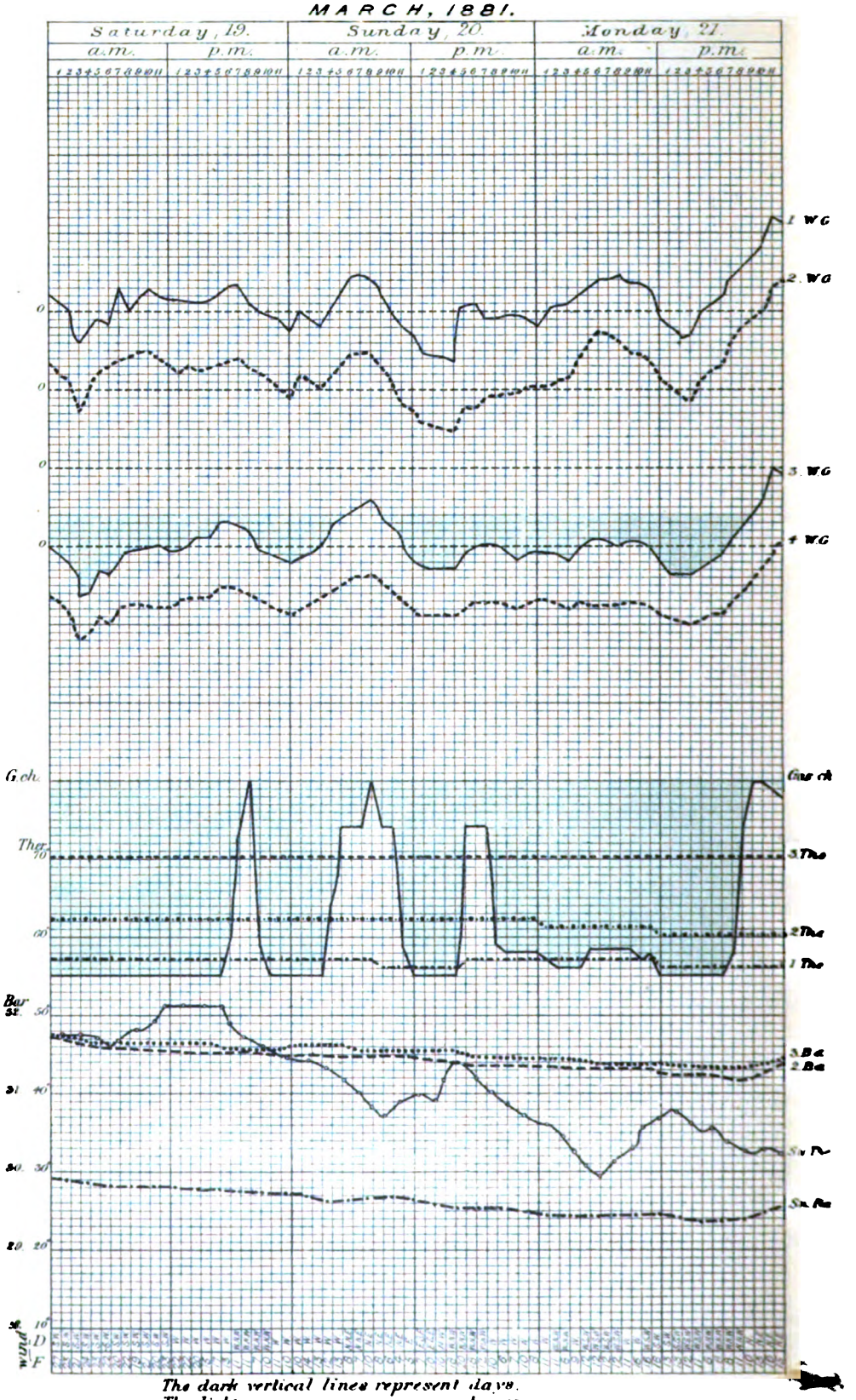

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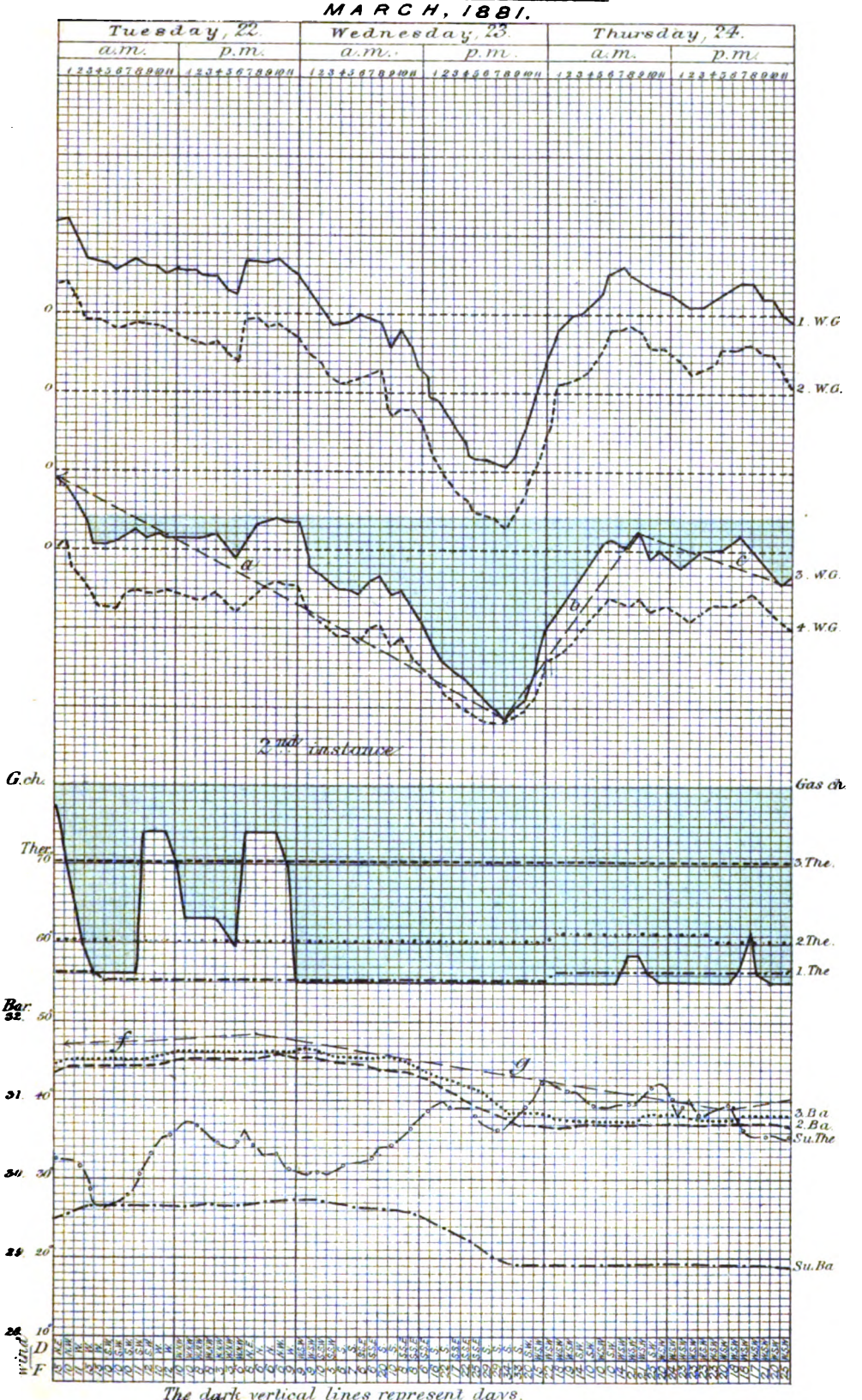

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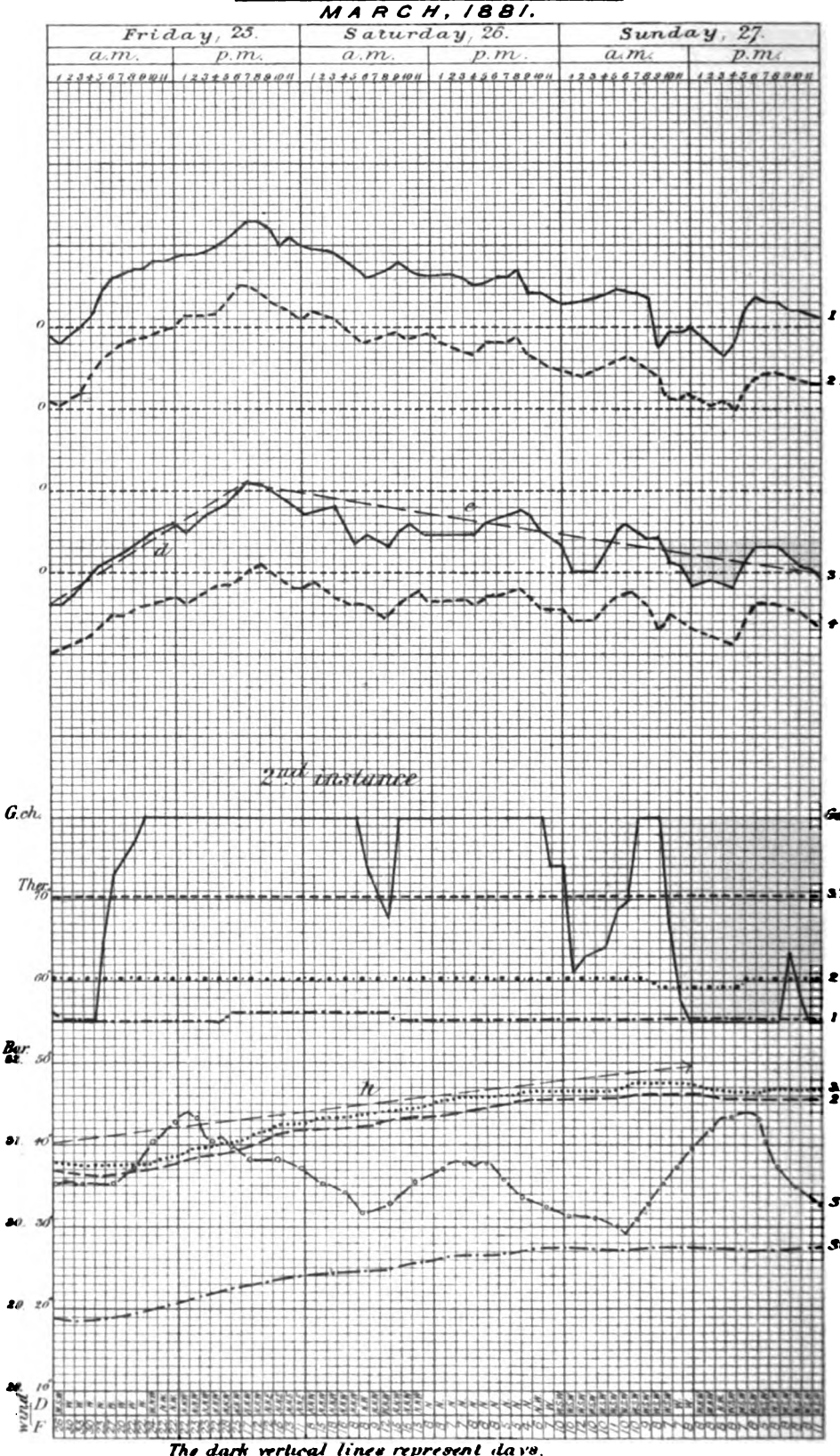

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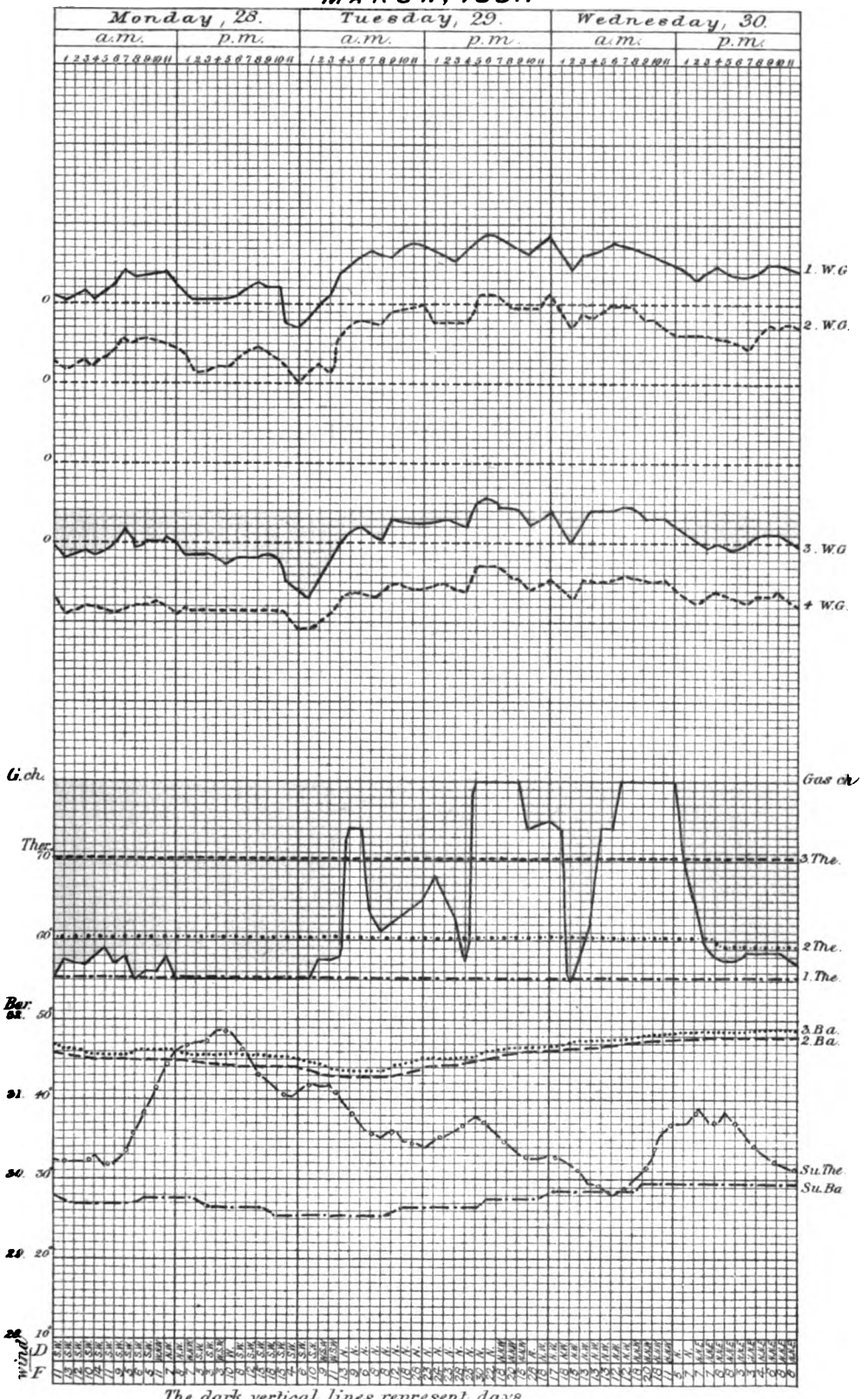

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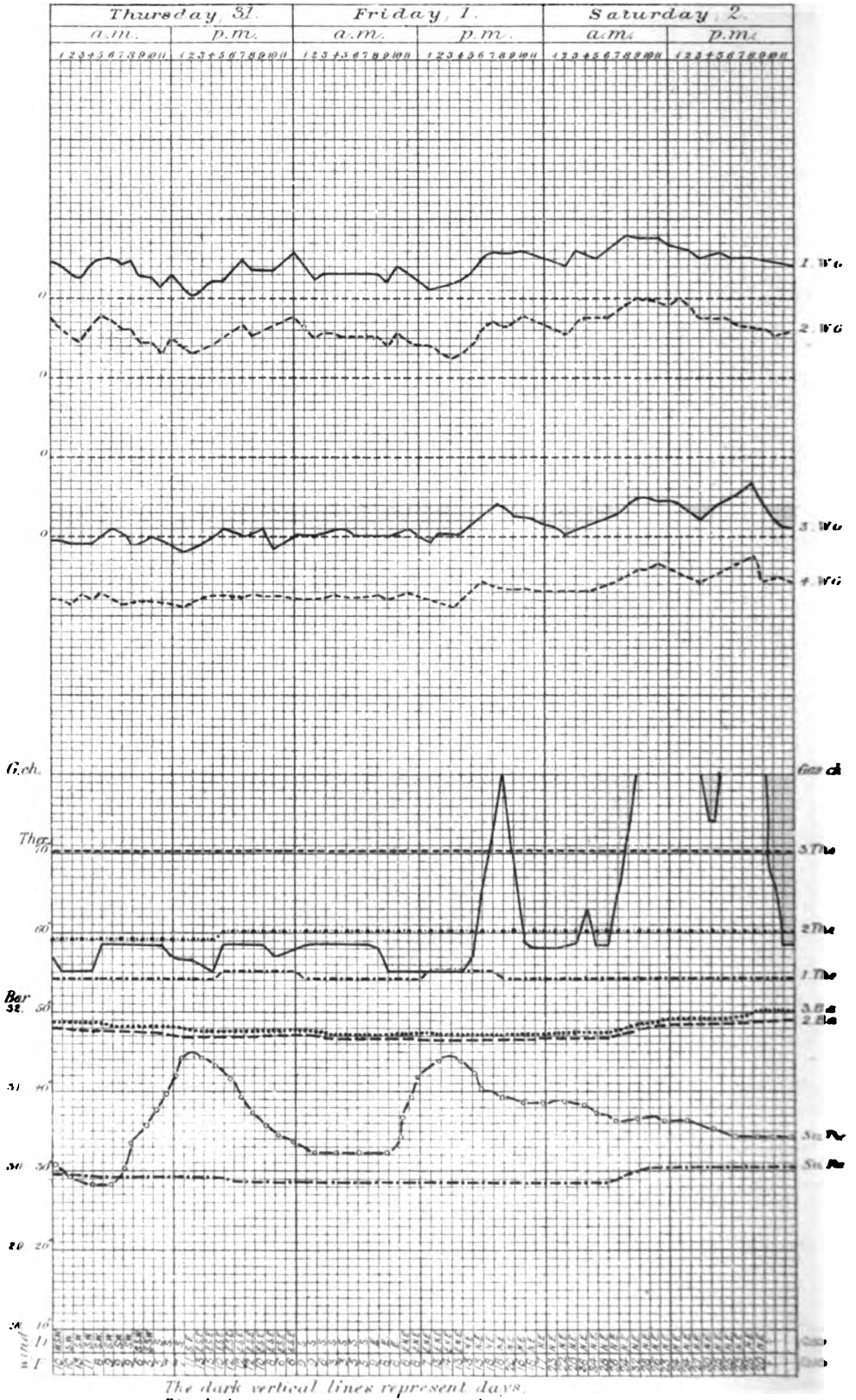

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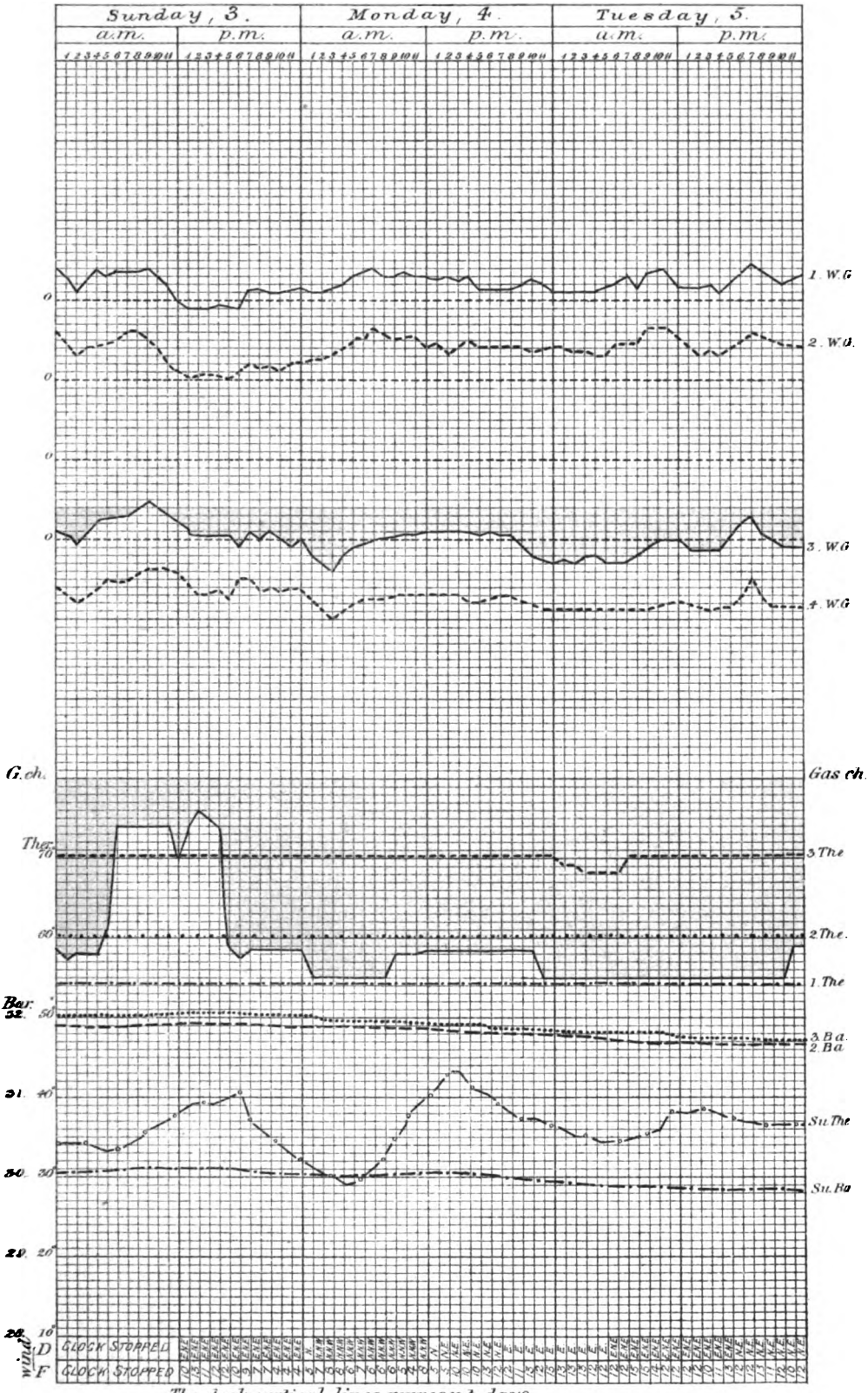

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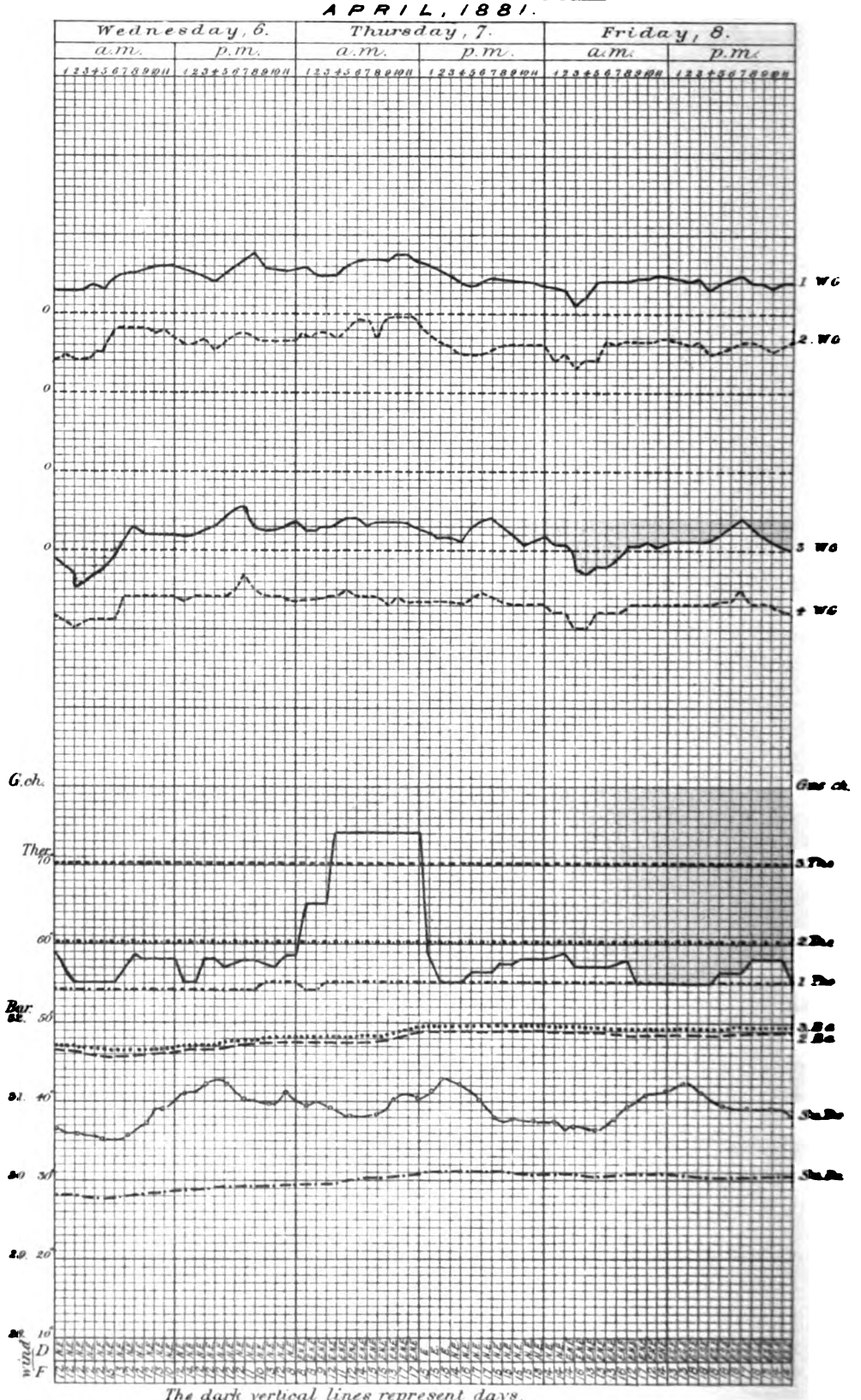

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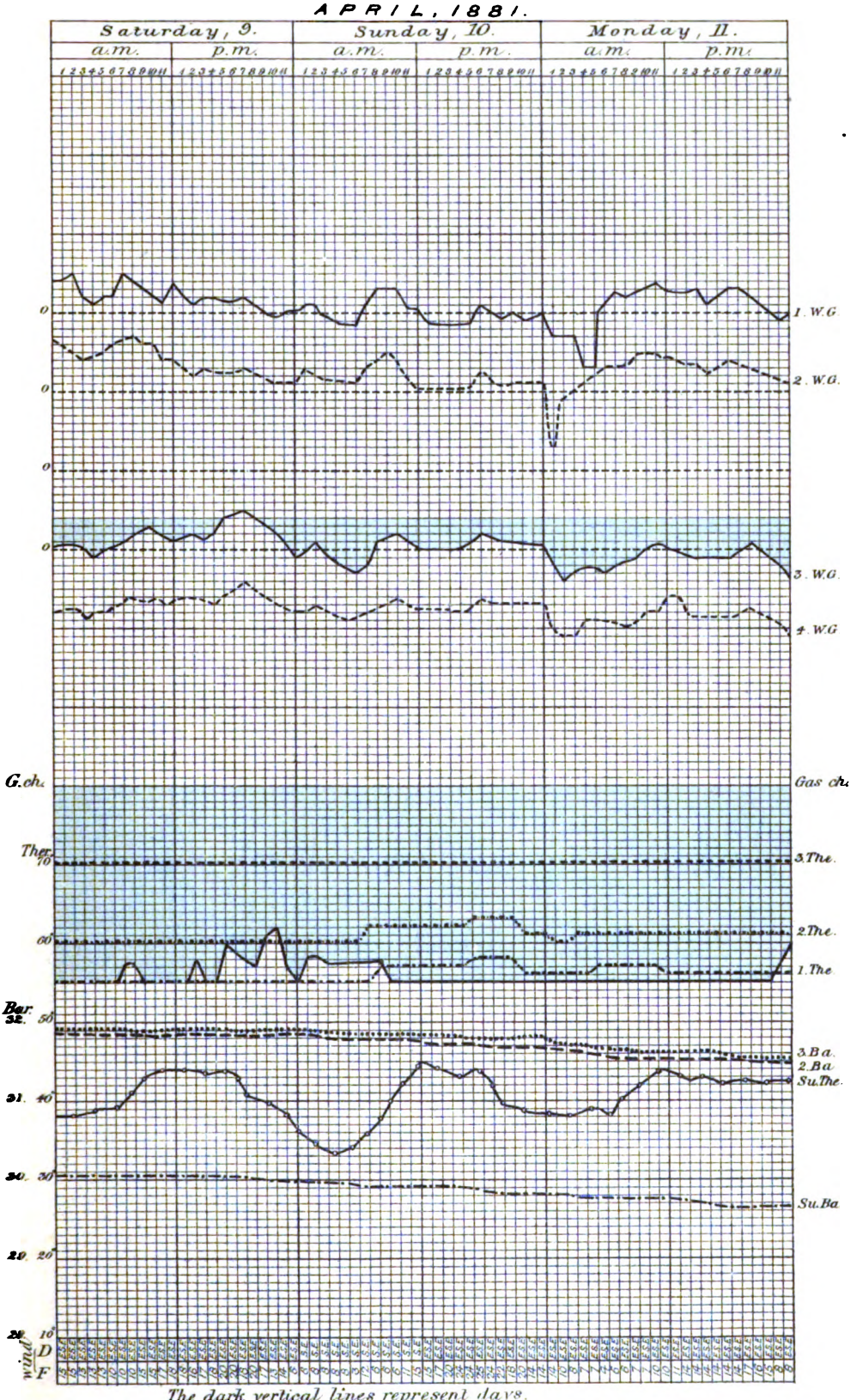

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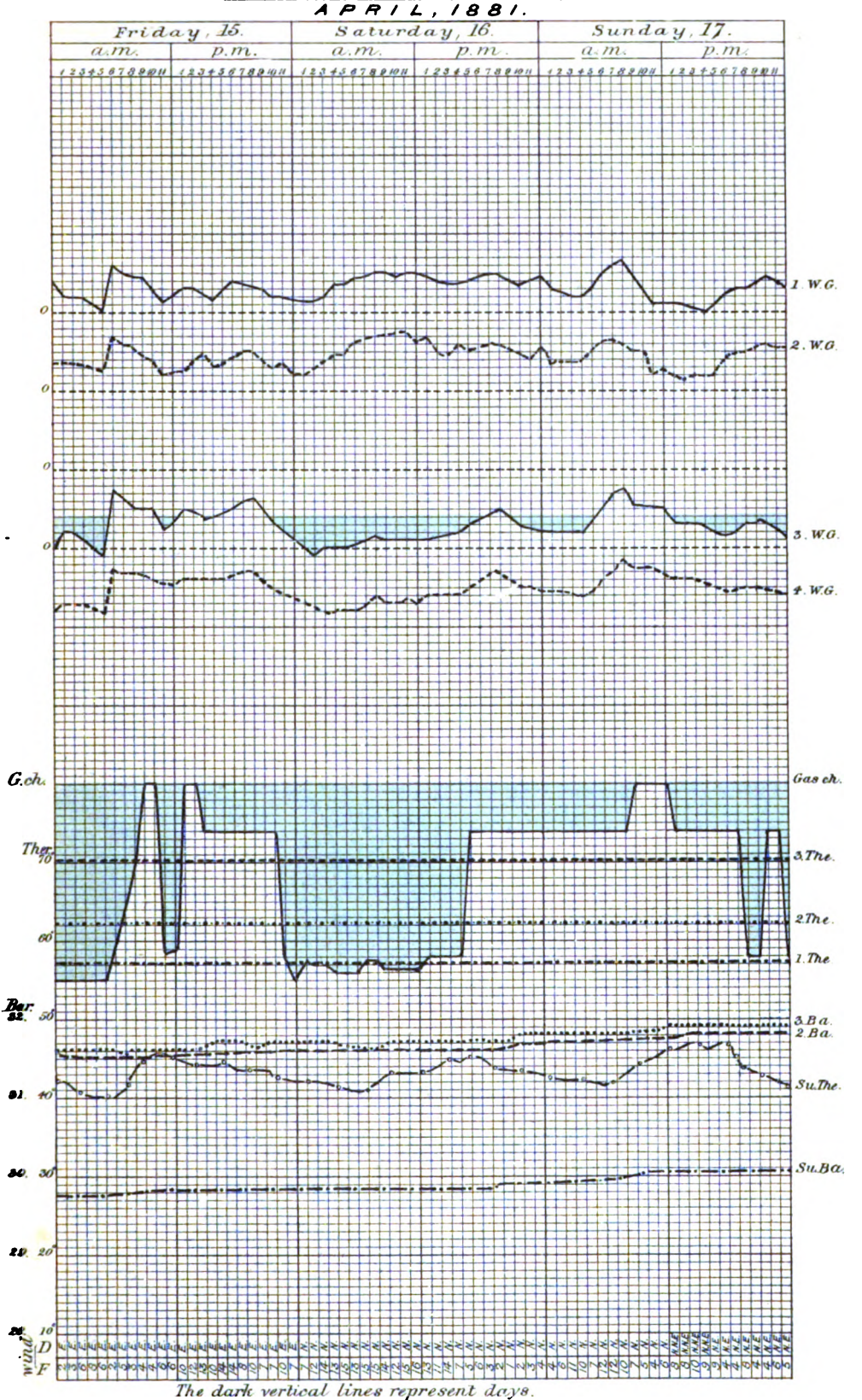

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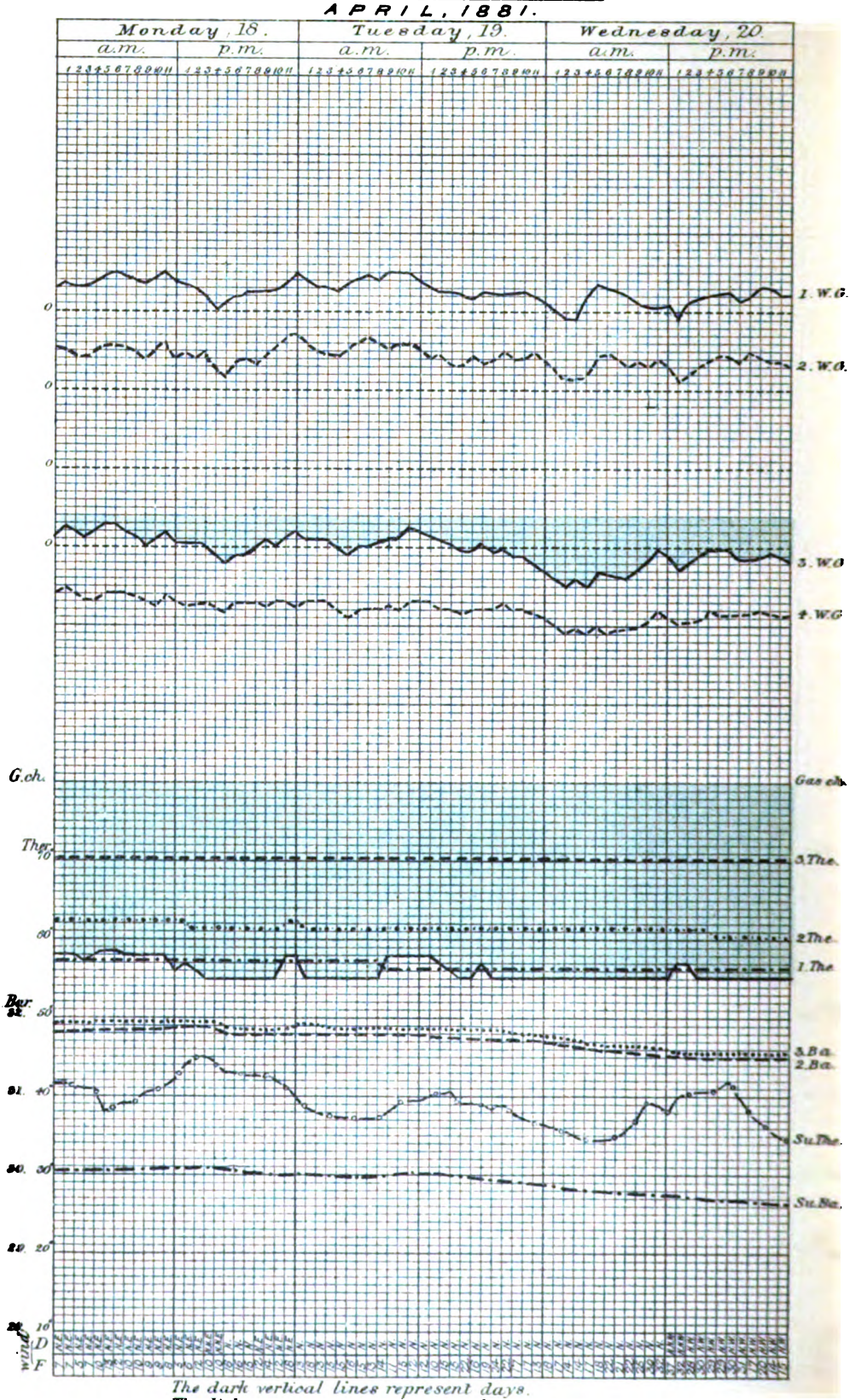

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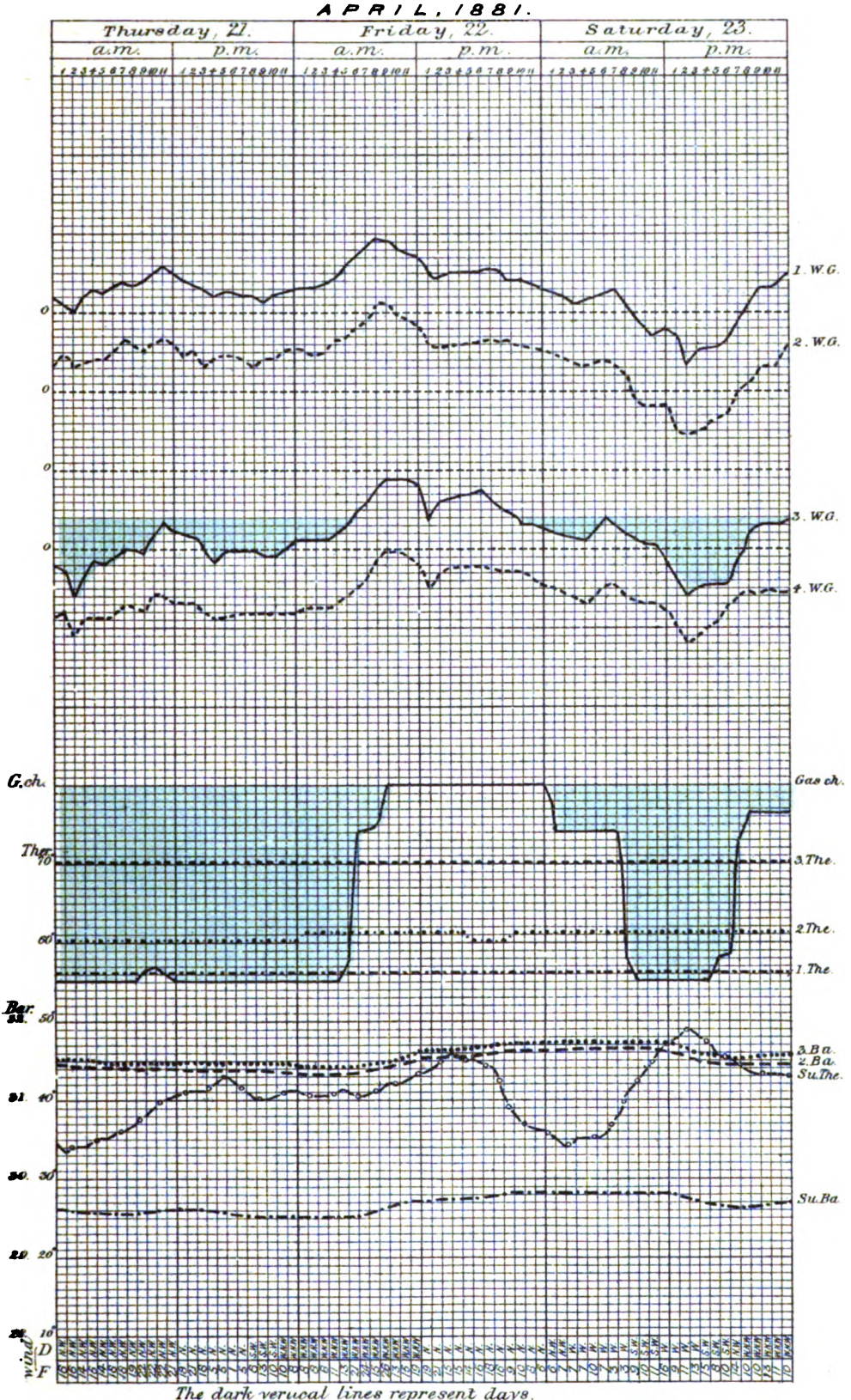

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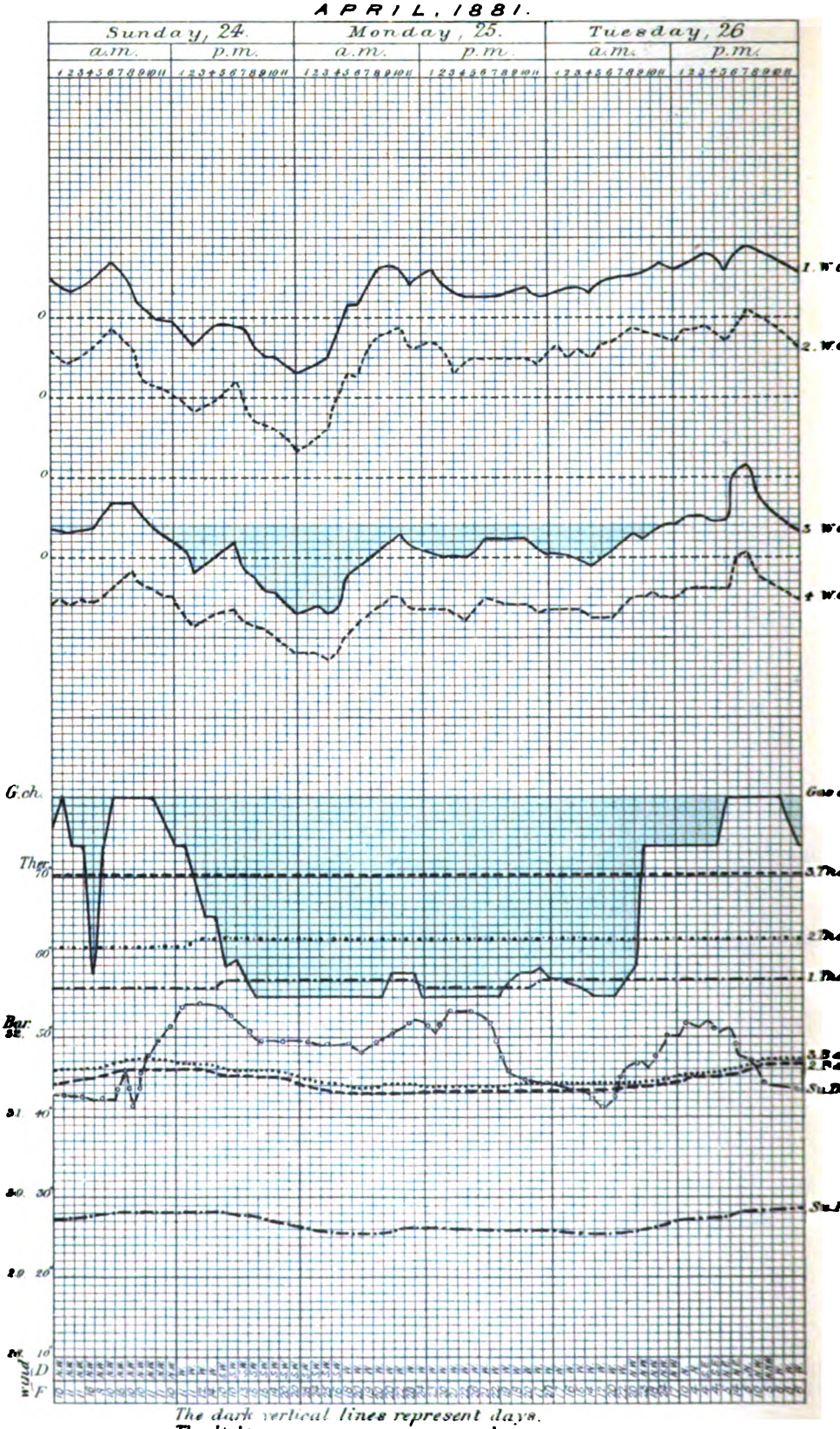

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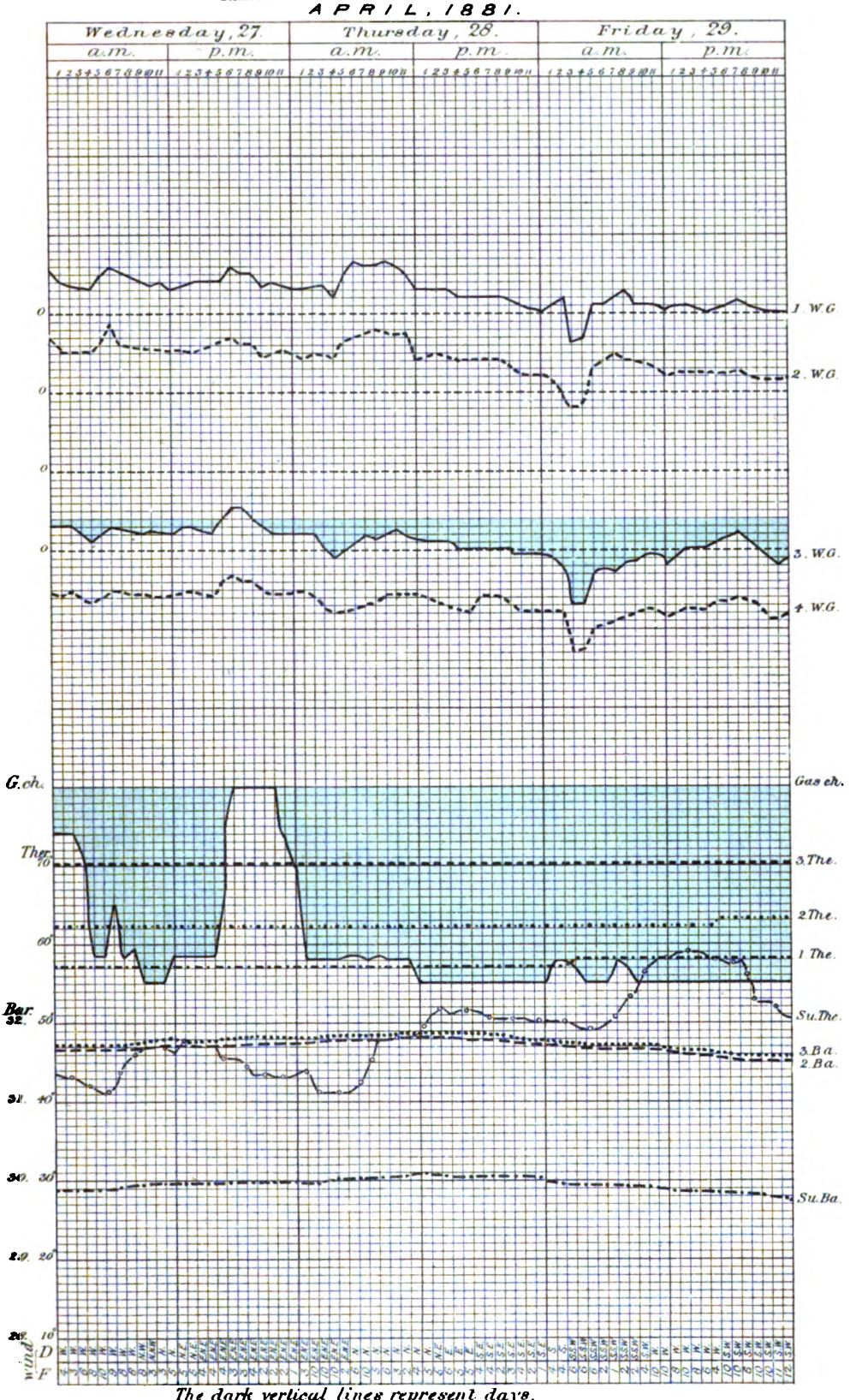

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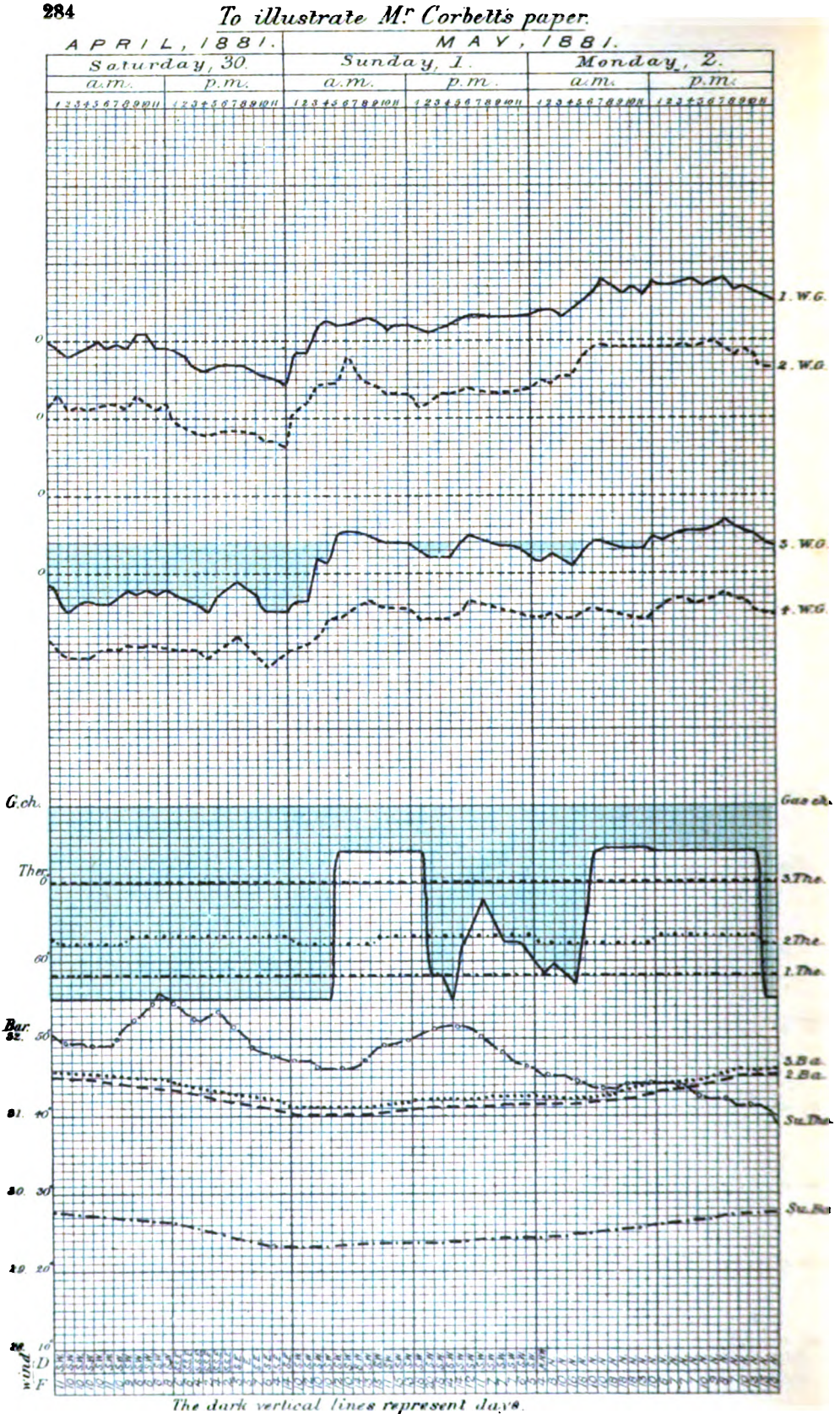

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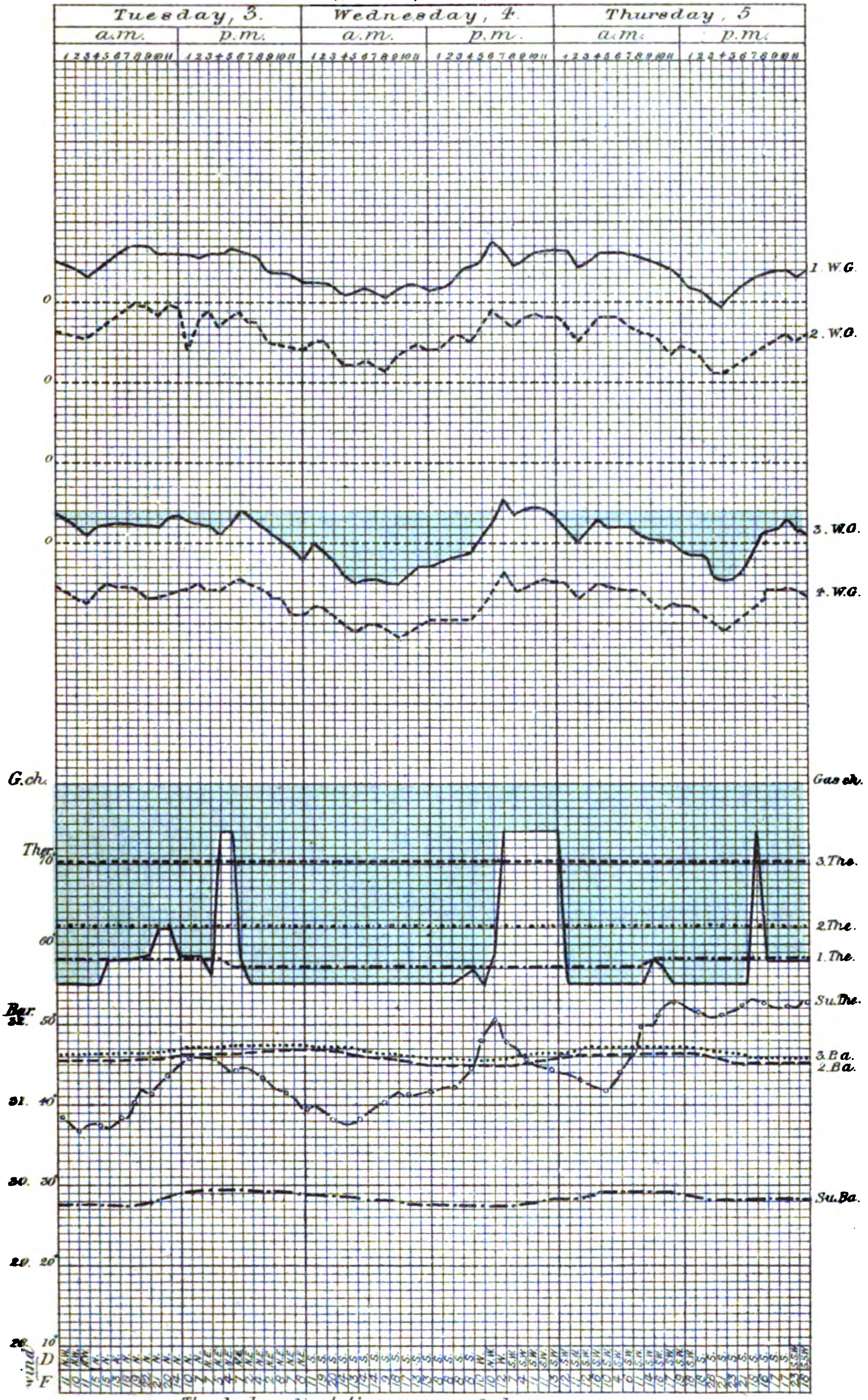

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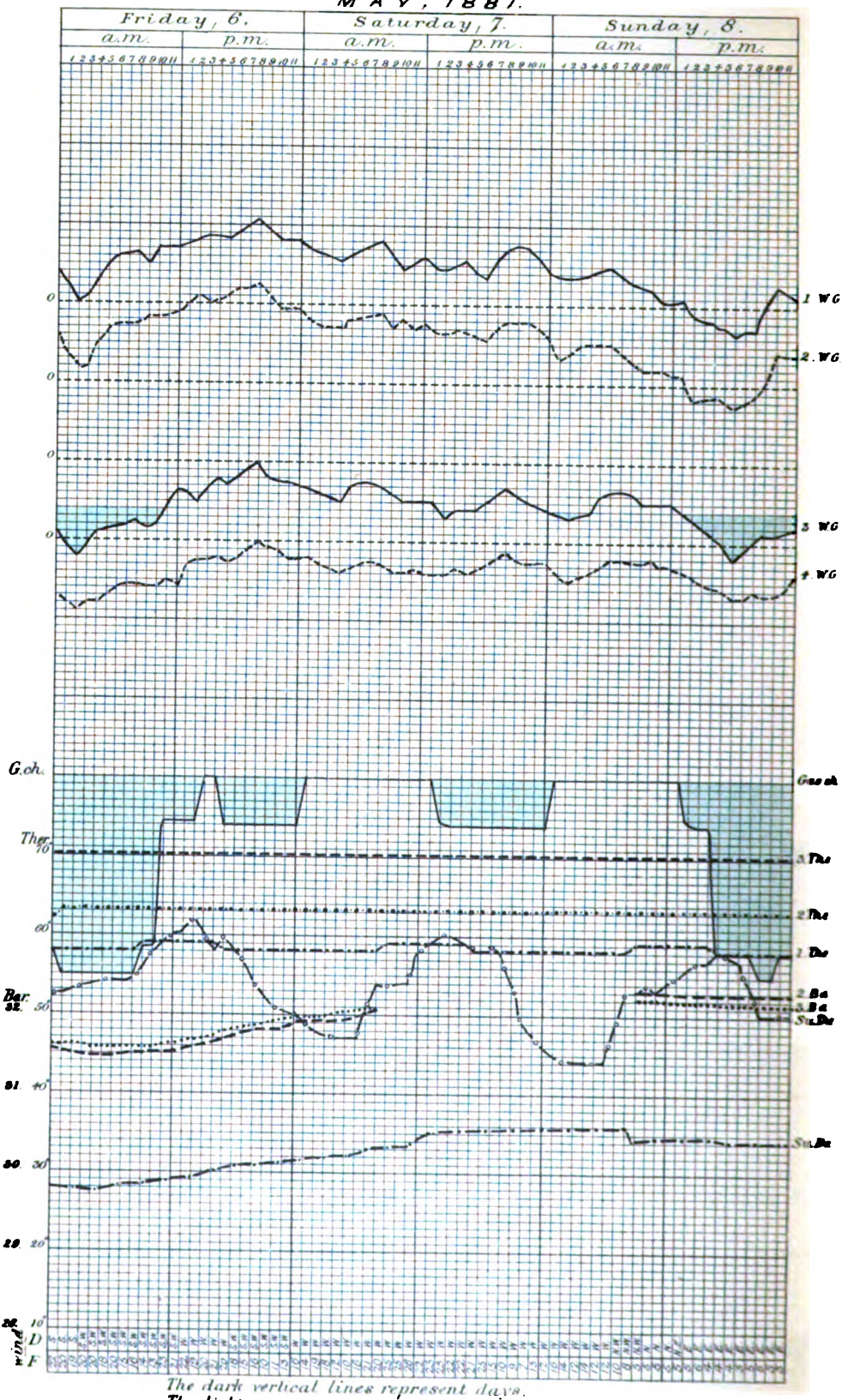

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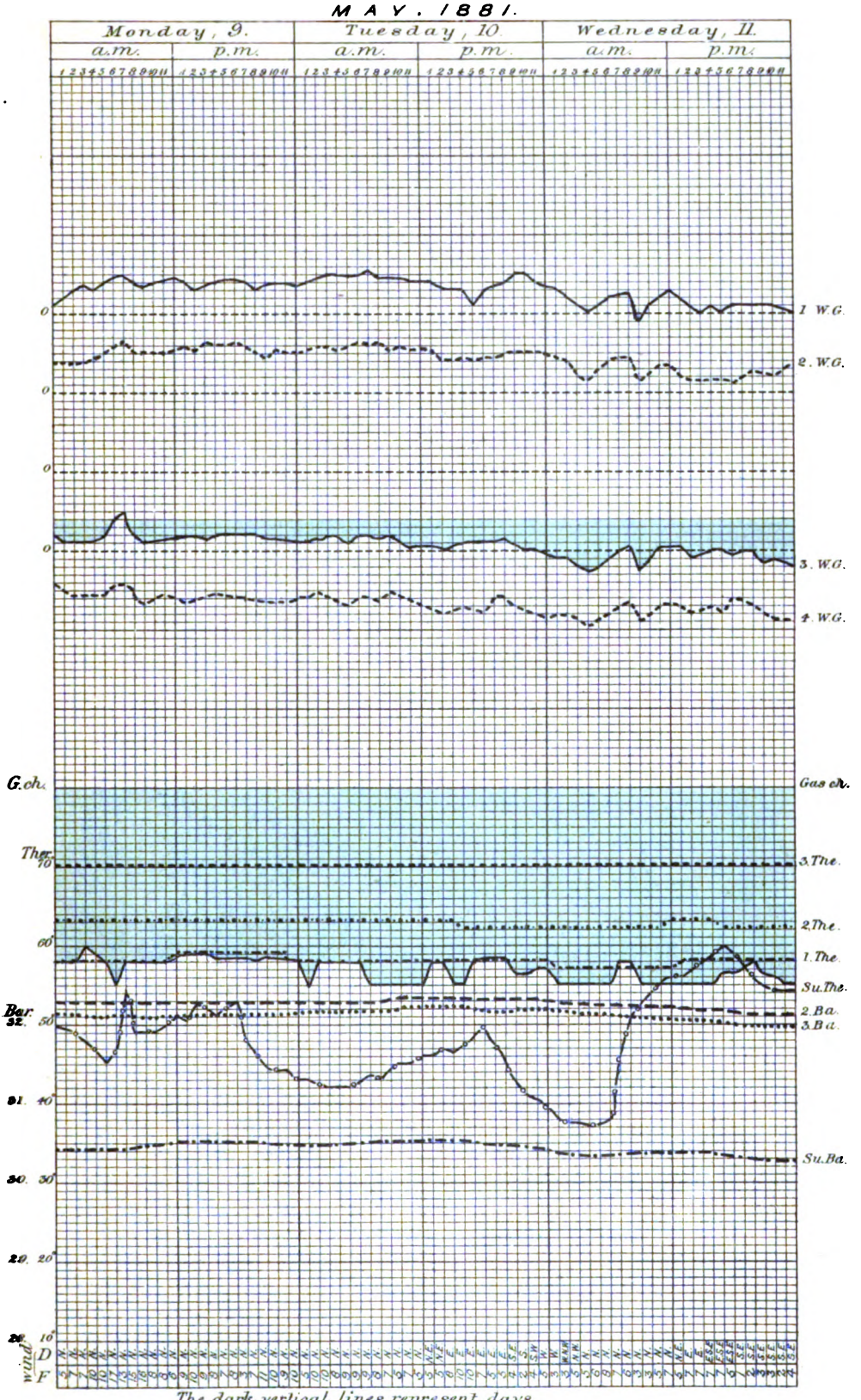

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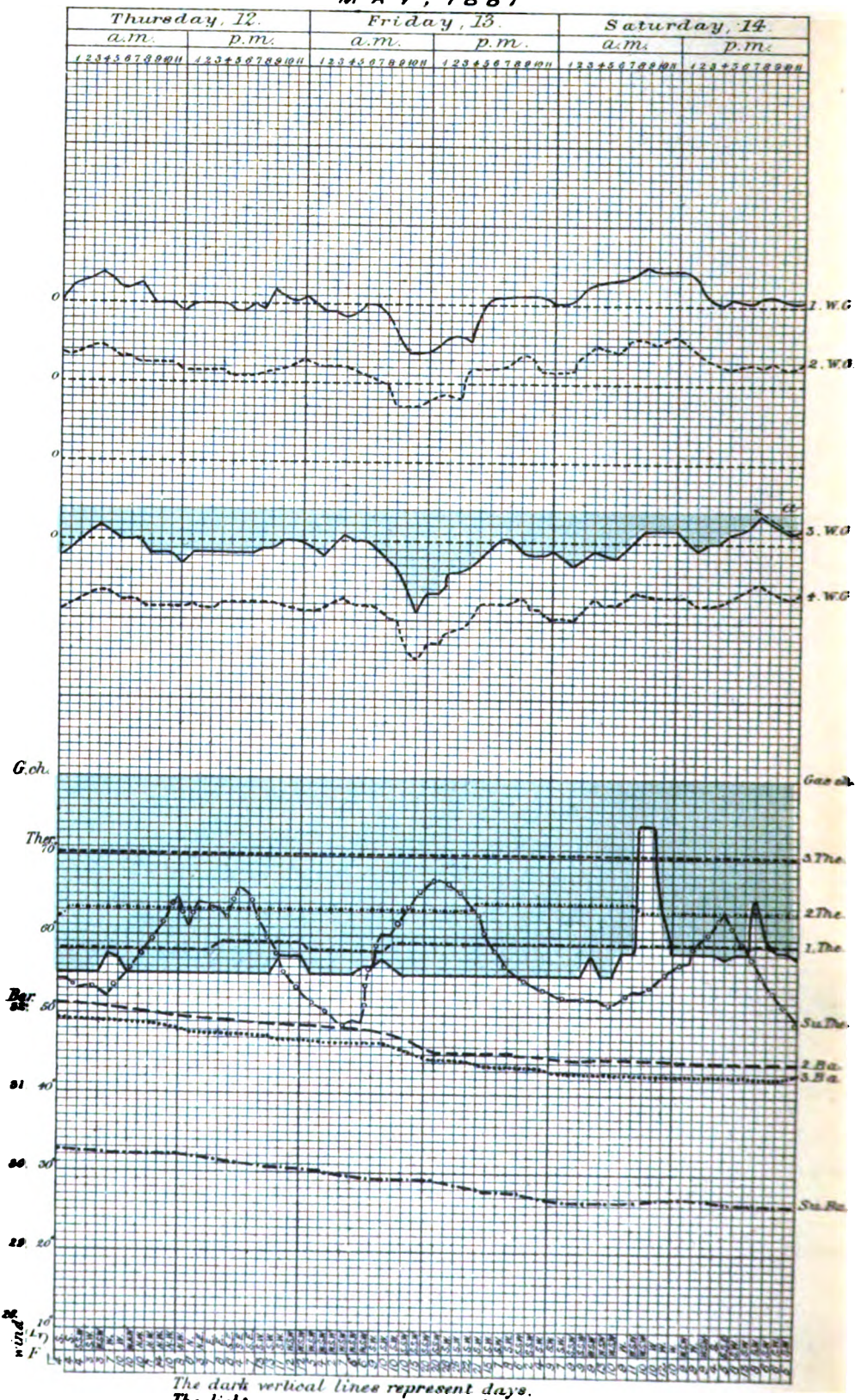

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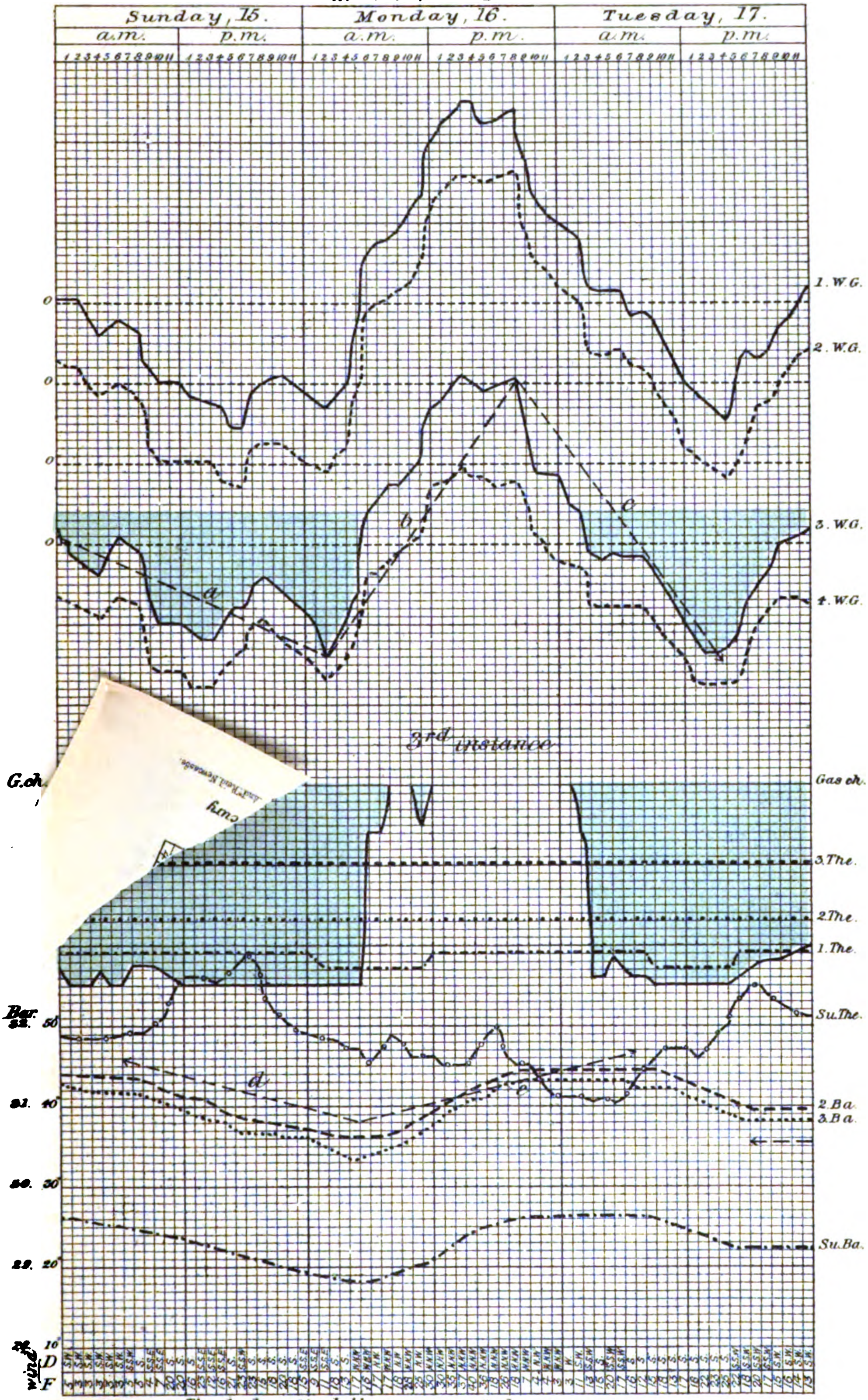

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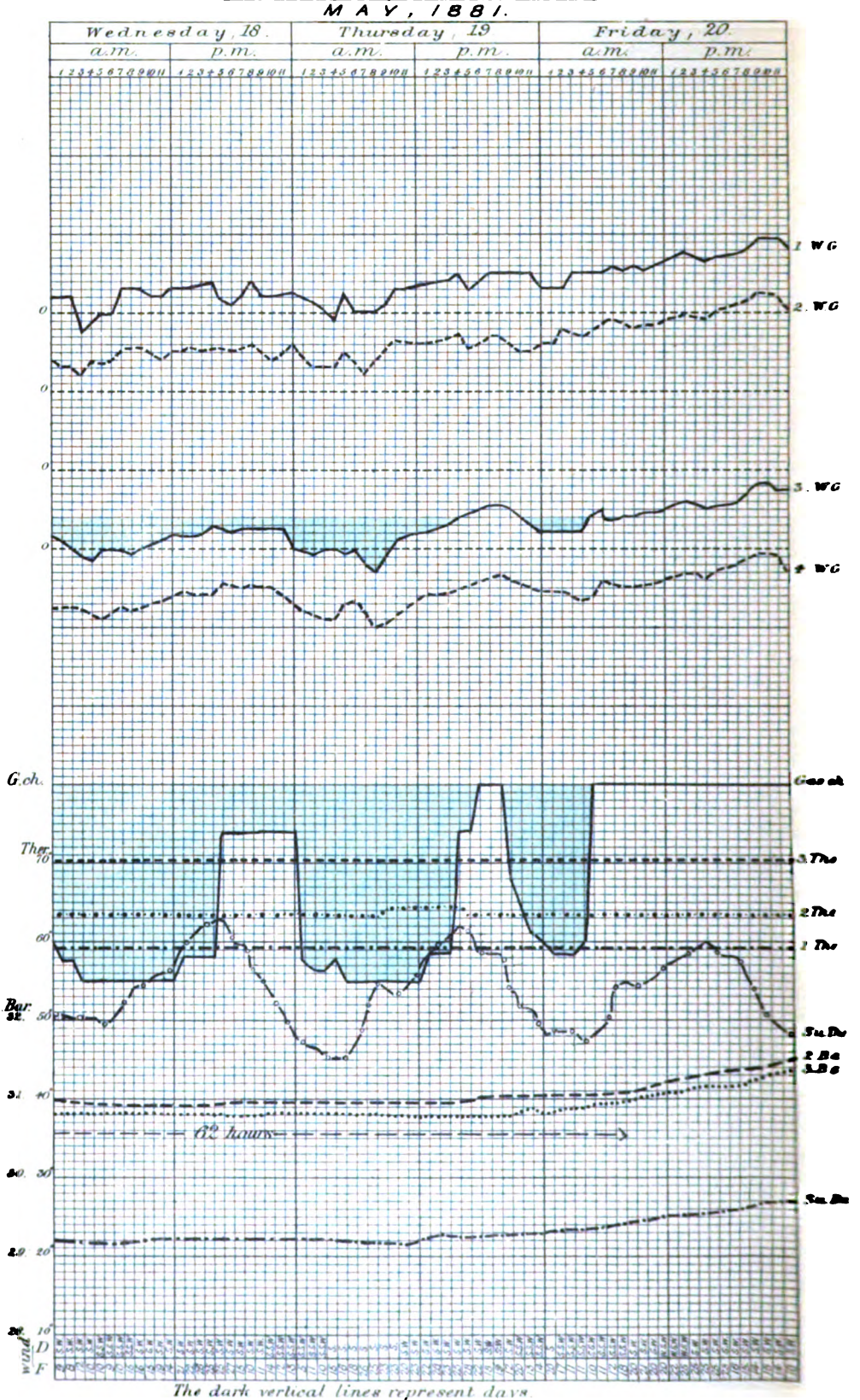

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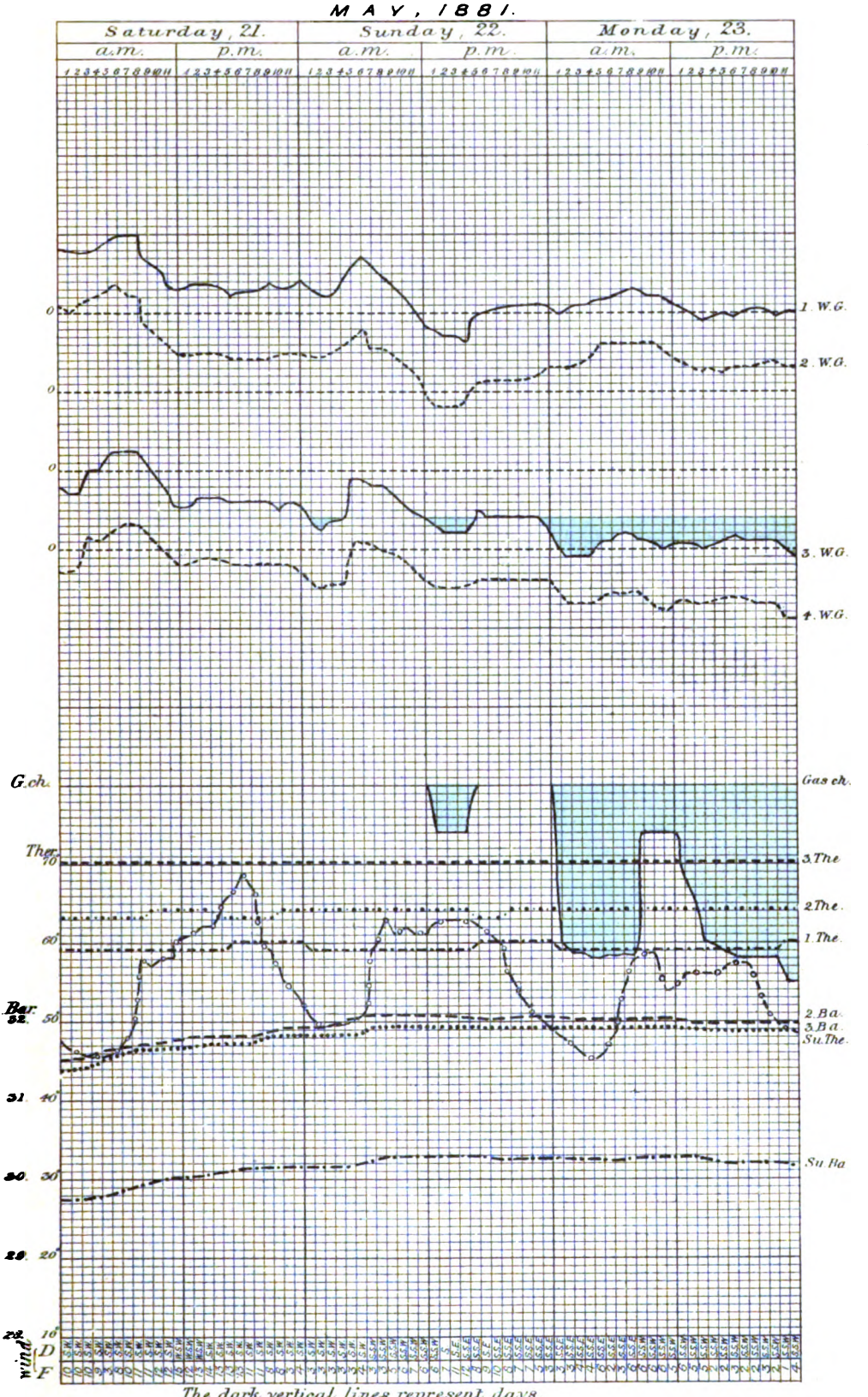

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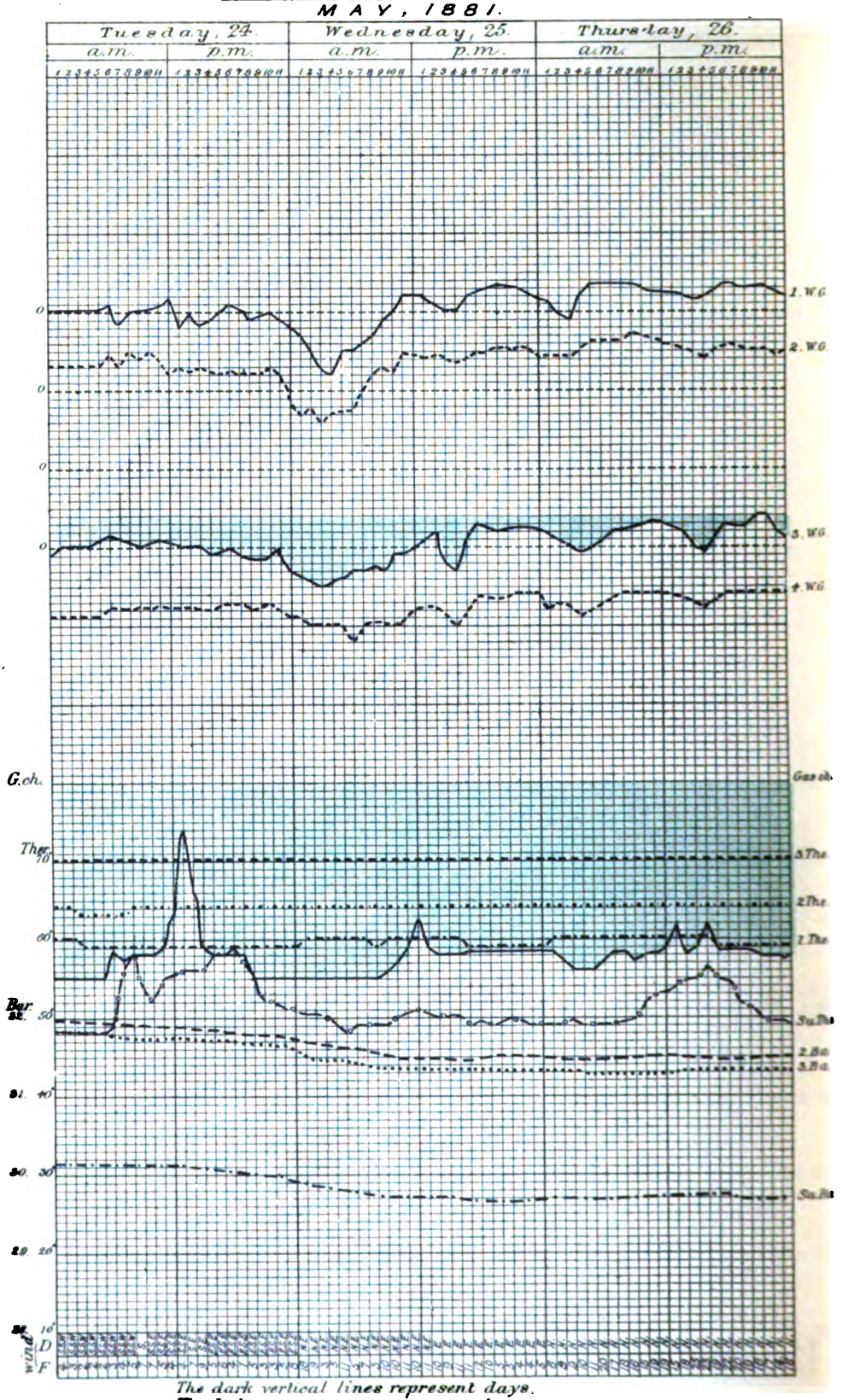

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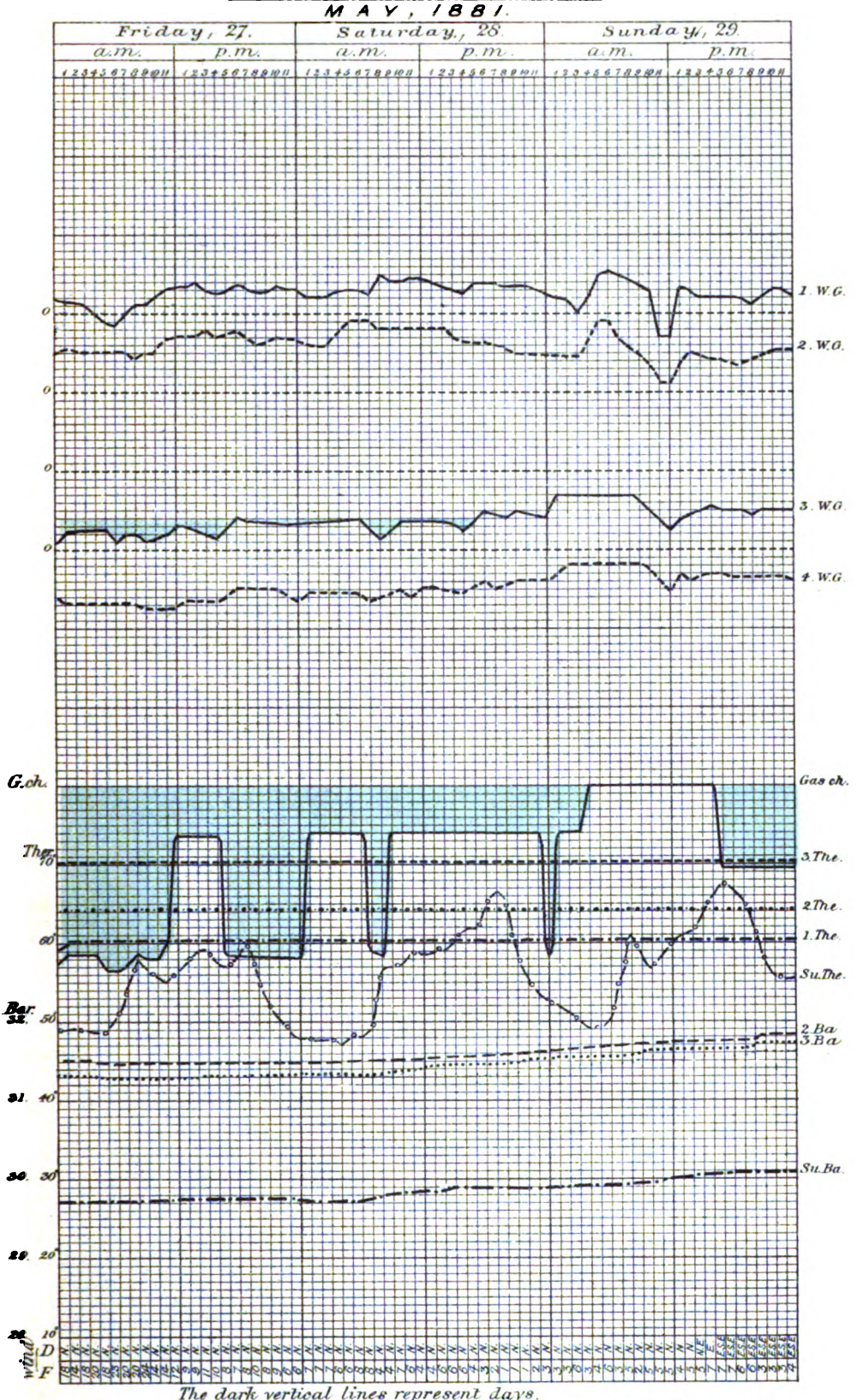

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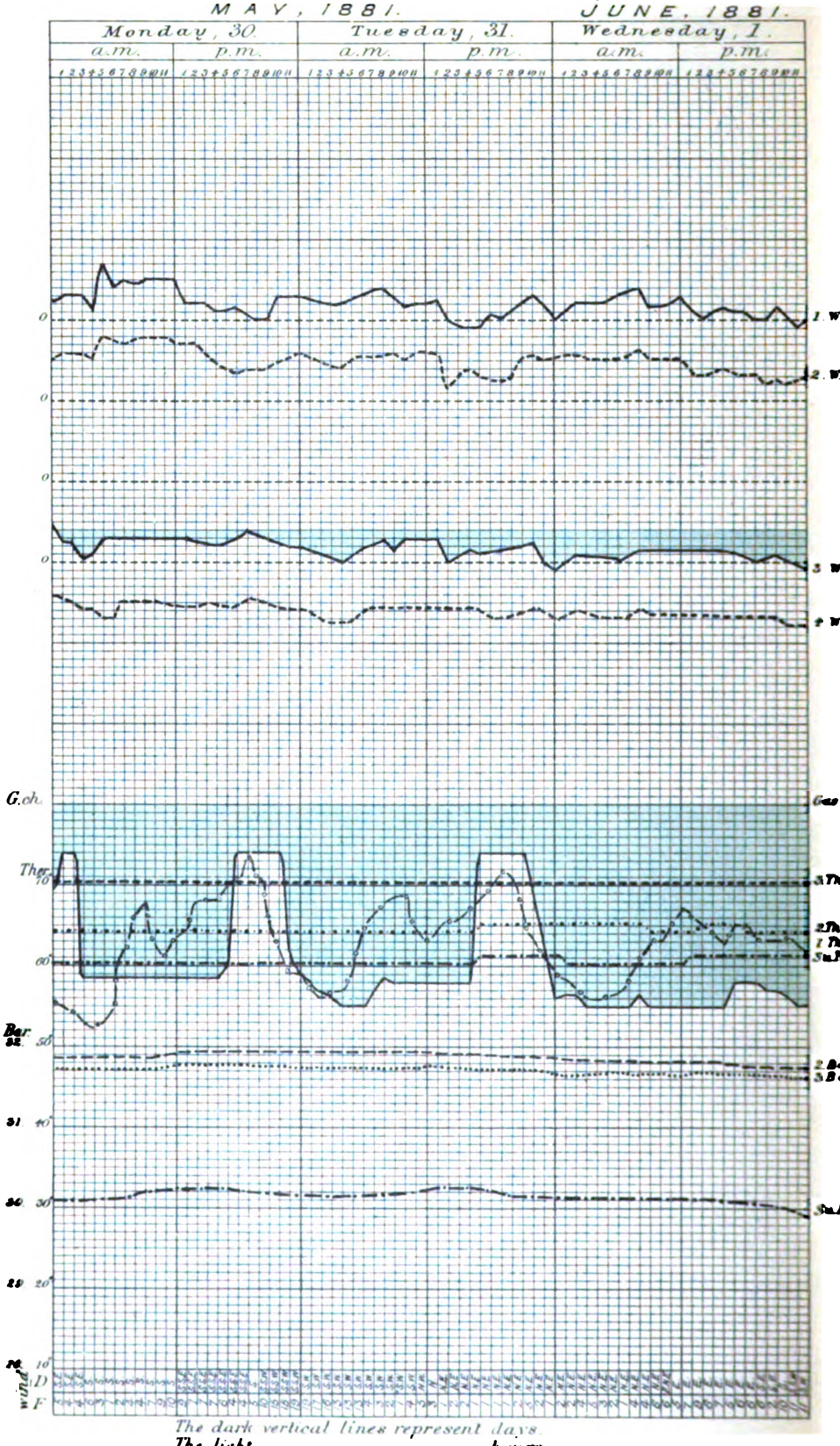

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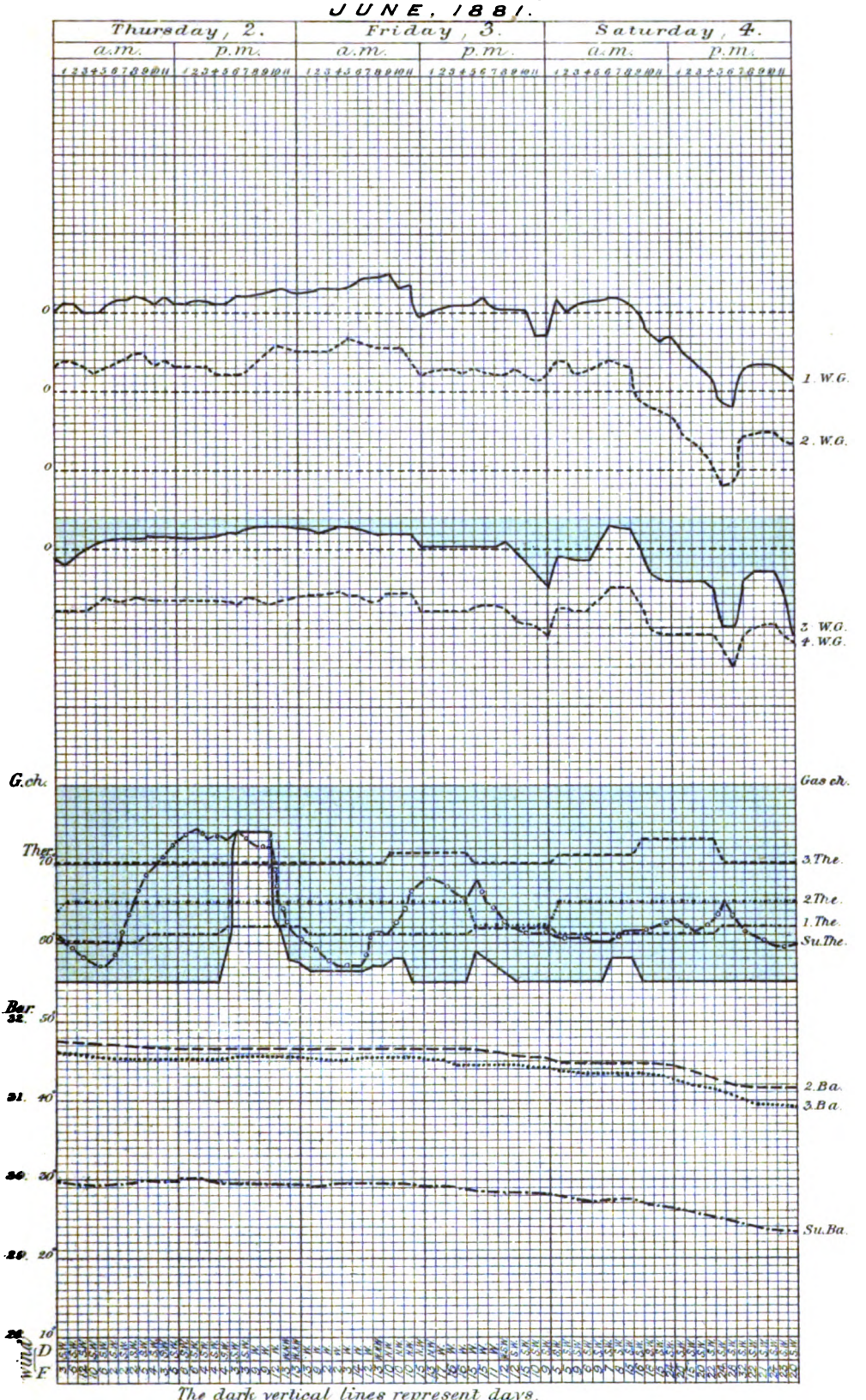

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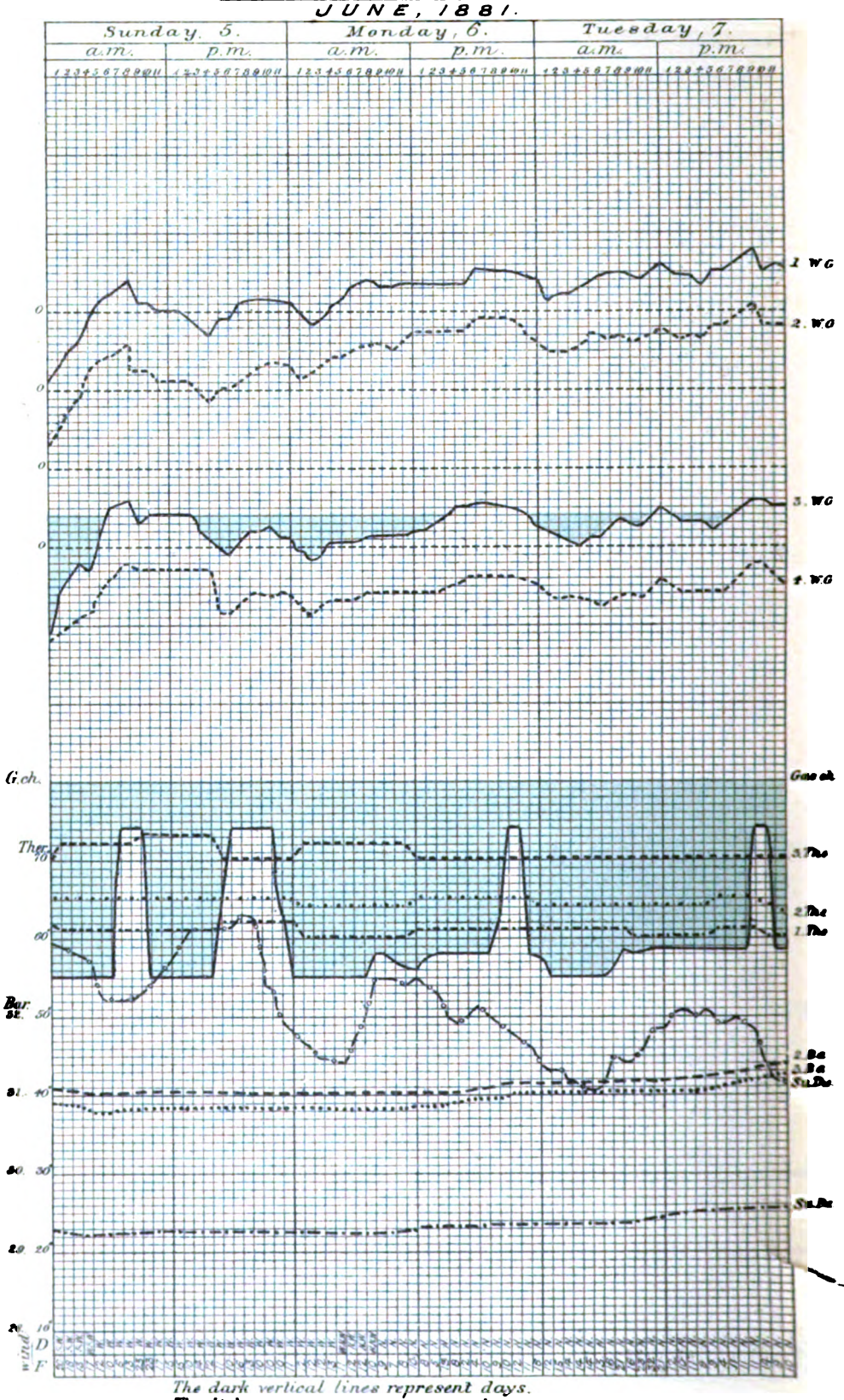

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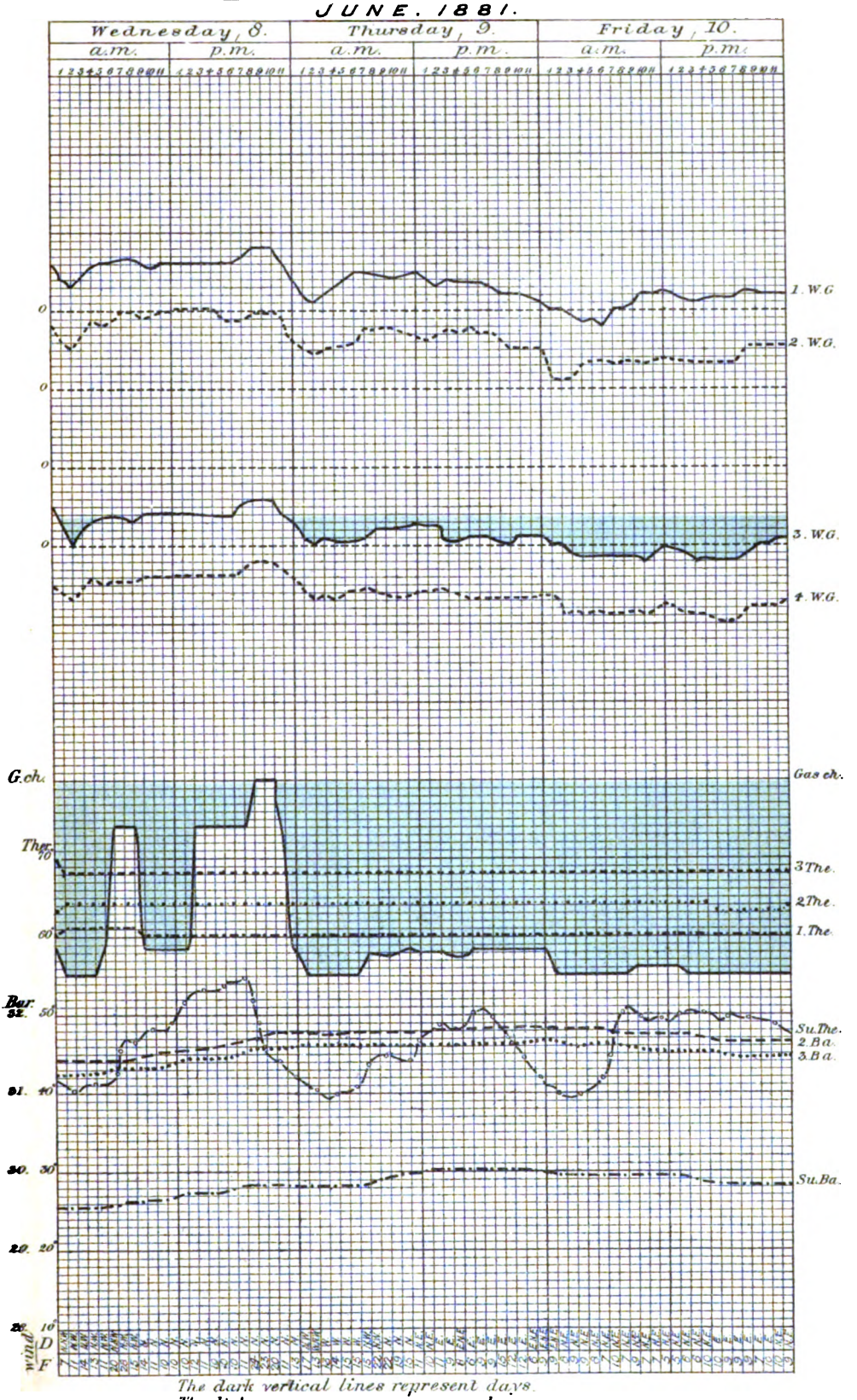

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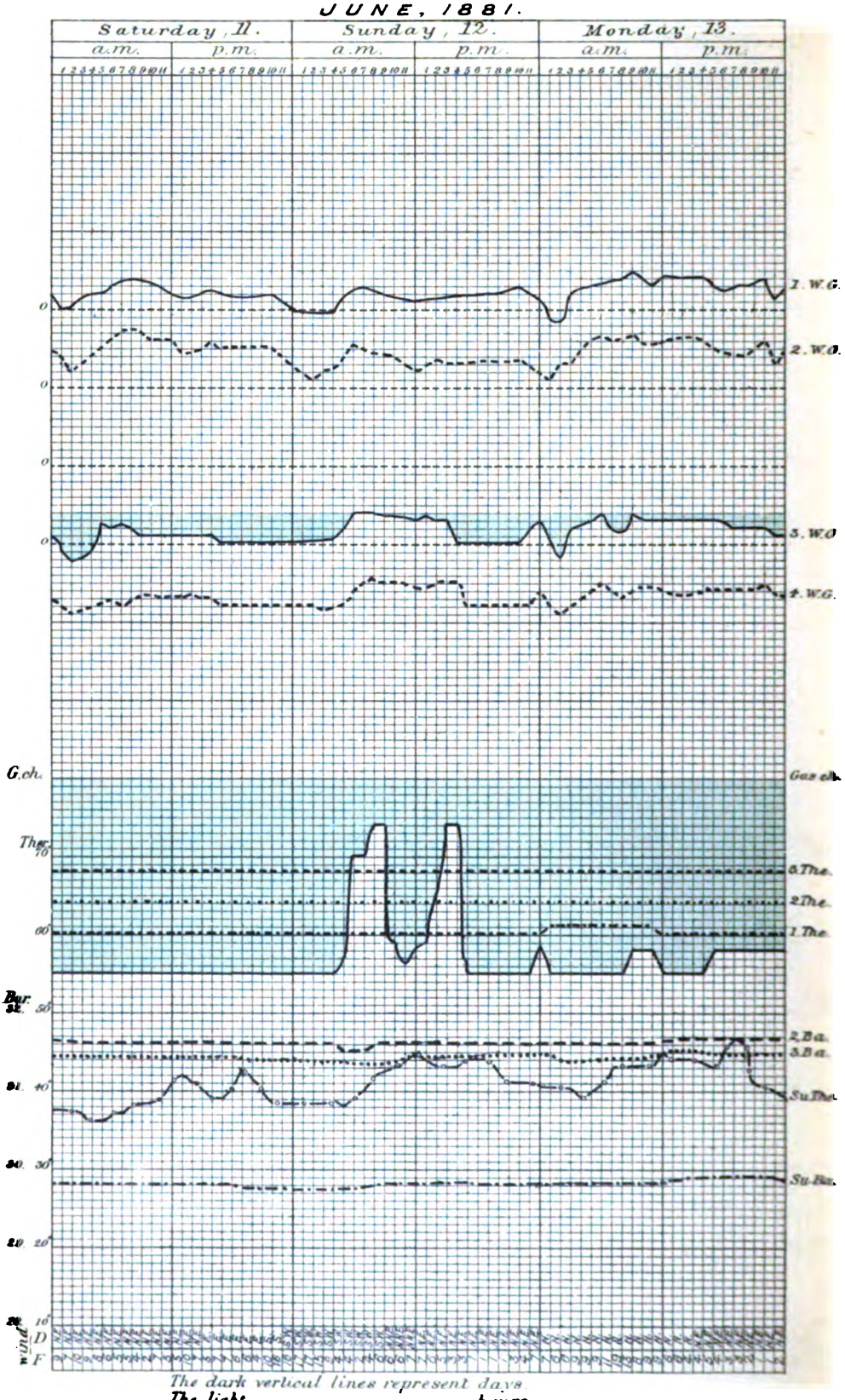

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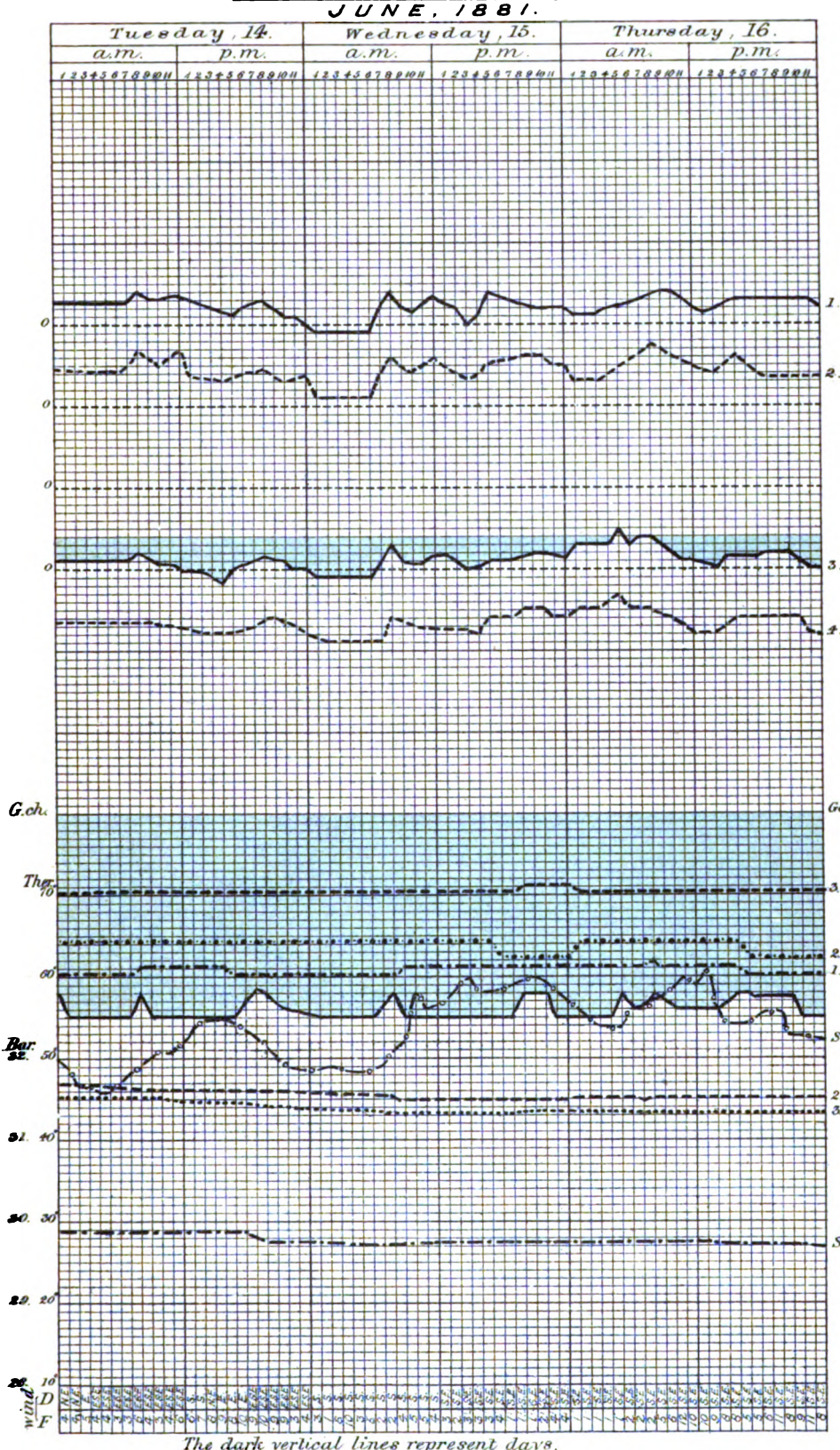

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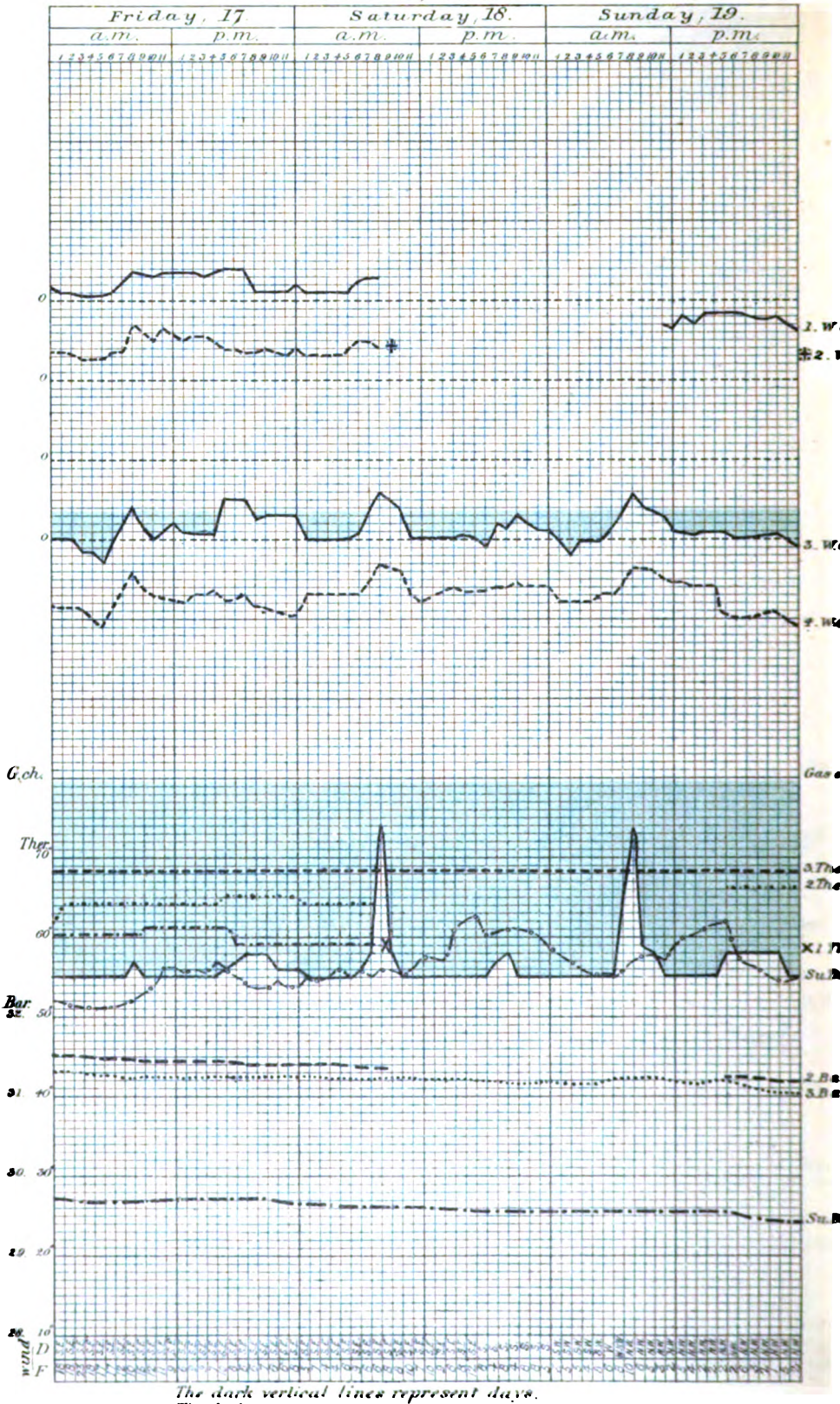

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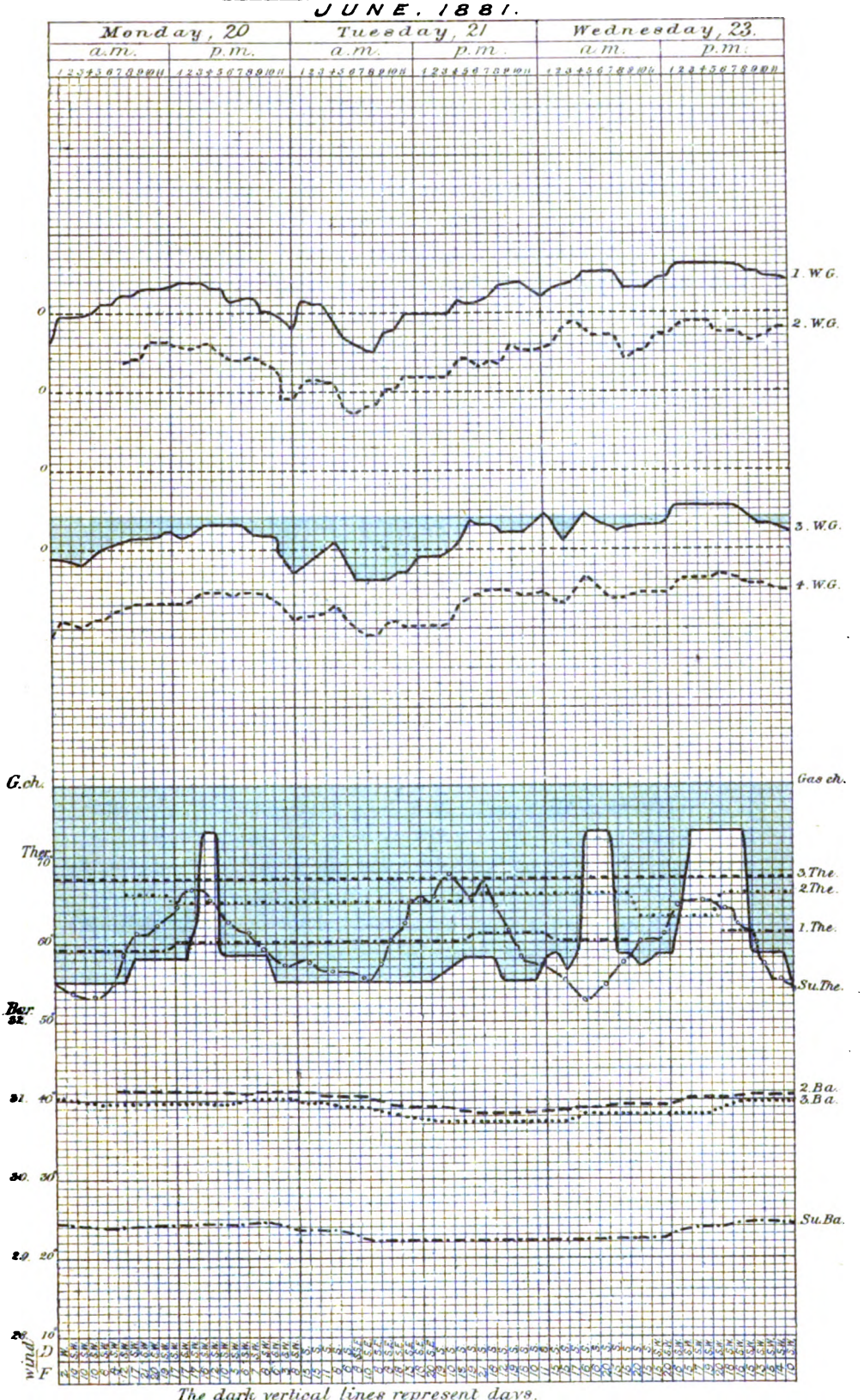

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And. Rod. Fernando.

FIRST COMPARISON.

BETWEEN No. 3 WATER-GAUGE AND No. 3 BAROMETER.

FIRST INSTANCE.

By the water-gauge a depression commences on Saturday, the 5th of February, at 5 p.m.; this depression continues gradually till Sunday, the 6th, at 10 p.m. (line *a*), when a rapid fall commences, the lowest point being obtained on Monday, the 7th, at 6 p.m. (line *b*), a rapid rise then occurs; the highest point is reached on Tuesday, the 8th, at 7 p.m. (line *c*). A slight fluctuation then occurs up to Wednesday, the 9th, at 8 a.m. (line *d*), when there is another great depression, the lowest point being obtained on Thursday, the 10th, at 2 a.m. (line *e*). From this hour there is a quick rise, the highest point being reached on Friday, the 11th, at 3 a.m. (line *f*). From this hour an out-bye pressure prevails (generally) till noon on the 13th (line *g*).

To obtain a comparison between the water-gauge and the barometer, it is found that during the time the water-gauge is showing a depression (line *a*) the barometer is rising; the centre of this is reached on Monday, the 7th, at about 1 a.m. (line *h*), but the depression, according to the barometer, does not begin till 4 a.m. the same day (line *i*). In this instance the barometer commences to show a depression thirty-five hours after the water-gauge. The centre of this depression, as shown by the barometer (line *i*), may be taken on Tuesday, the 8th, at 8 a.m., but there is no rise shown till 11 a.m. the same day; in this instance it is seventeen hours behind the water-gauge. The centre of the rise of the barometer may be assumed to be on Wednesday, the 9th, at 2 p.m. (line *j*), and a depression is shown as commencing at 6 p.m. the same day, or twenty-three hours after the depression is marked by the water-gauge. A fall of barometer now takes place, the centre of depression being on Thursday, the 10th, at about 3 p.m. (line *k*), but no rise is shown till 9 p.m. the same day, or nineteen hours after the water-gauge. A rise now occurs (line *l*). The centre of this rise may be assumed at 7 p.m., on the 12th, and no depression is marked till 3 a.m., on the 13th, and then for several hours the fall is very slight; the barometer in this instance marks a depression forty-eight hours after the water-gauge.

SECOND INSTANCE.

The water-gauge shows a depression, commencing on Monday, the 21st of March, at 11 p.m. (with the exception of a slight rise between 6 p.m. and 10 p.m. on the 22nd), and ending on Wednesday, the 23rd, at 8 p.m. (line *a*). A sudden rise then takes place, the highest point

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reached is on Thursday, the 24th, at 9 a.m. (line *b*); from this time a slight fall occurs (line *c*), the lowest point being reached at 11 p.m. the same day, then a rise to Friday, the 25th, at 7 p.m. (line *d*). A gradual outbye pressure now commences (line *e*). The barometrical readings show that from Tuesday, the 22nd, at 1 a.m. till 8 p.m. the same day the mercury rises (line *f*); a depression then commences (line *g*), the barometer, therefore, marks that depression twenty-one hours after the water-gauge. This depression as shown by the barometer is of long continuance, and no rise is marked till Friday, the 25th, at 5 a.m. (line *h*), this is thirty-three hours after the water-gauge. From Wednesday, the 23rd, at 8 p.m., to Thursday, the 24th, at 8 a.m. (line *b*) it will be noticed the water-gauge makes a sudden rise; from Thursday, the 24th, at 9 a.m. to 11 p.m. on the same day, a fall occurs (line *c*), the barometer in the meanwhile continuing steady; after this the water-gauge and barometer rise, the water-gauge acting about six hours before the barometer. The centre of this rise may be assumed to be at noon, on the 27th, forty-one hours after the water-gauge, after which the barometer continues steady for some time.

THIRD INSTANCE.

The water-gauge shows a depression commencing on Saturday, the 14th of May, at 8 p.m., reaching the lowest point on Monday, the 16th, at 2 a.m. (line *a*). A rapid rise from Monday, the 16th, at 2 a.m. till 8 p.m. the same day (line *b*). A rapid fall from Monday, the 16th, at 8 p.m. till Tuesday, the 17th, at 3 p.m. (line *c*); then a rise. The barometer shows a fall commencing on Sunday, the 15th, at 3 a.m., or seven hours after the water-gauge (line *d*); a rise commencing on Monday, the 16th, at 6 a.m. (line *e*), or four hours after the water-gauge. The barometer then shows no depression till Tuesday, the 17th, at 7 a.m., or eleven hours after the water-gauge; after this a fall and a steady barometer for some time, as against a rise and steady water-gauge.

SECOND COMPARISON.

BETWEEN No. 2 WATER-GAUGE AND THE GAS-CHECK.

FIRST INSTANCE.

The gas-check shows that the place is practically free from gas on Saturday, the 5th of February, at 9 a.m. At this hour No. 2 water-gauge registers 0·9 inch; the gas-check shows that the place remains comparatively free from gas till Sunday the 6th, at 10 p.m.; at the same hour the water-gauge registers 0·7 inch; according to the gas-check, gas

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then makes its appearance, and so continues till Tuesday, the 8th, at 3 p.m., when the place is again free from gas, the water-gauge reading at that hour is 1·1 inch. After this the gas-check shows the place free from gas till Wednesday, the 9th, at 9 a.m, the water-gauge registering 1·2 inch; after this the gas-check shows gas till Thursday, the 10th, at 8 p.m., when the reading is 0·4 inch. The place remains free from gas till Saturday, the 12th, at 5 p.m., the water-gauge still registering 0·4 inch.

SECOND INSTANCE.

The gas-check shows the place is free from gas on Monday, the 21st of March, at 9 p.m., and at the same time the water-gauge reading is 0·9 inch; the gas-check, however, shows presence of gas at 10 p.m., the water-gauge then registering 1·0 inch. The gas-check shows the place free from gas on Friday, the 25th, at 9 a.m., the water-gauge reading being then 0·9 inch; by the gas-check the place remains free from gas (with a slight exception correspondingly marked by the water-gauge) till Saturday, the 26th, at 10 p.m., the water-gauge reading at the same hour being 0·6 inch. The gas-check shows the place free from gas at 7 a.m. on the 27th, and remains so for two hours, the water-gauge reading 0·4 inch.

THIRD INSTANCE.

By the gas-check there is no gas on Monday, the 16th of May, at 8 a.m., at the same hour the water-gauge reads 1·0 inch. The place is comparatively free from gas till Tuesday, the 17th, at 1 a.m., by the gas check, the water-gauge reading then being 1·1 inch. The gas-check shows the place free from gas on Thursday, the 19th, at between 6 and 8 p.m., the water-gauge registering 0·6 and 0·7 inch respectively. The gas-check shows no gas on Friday, the 20th, at 5 a.m., the water-gauge reading then being 0·8 inch. The gas-check, with a slight exception (correspondingly marked by the water-gauge), shows the place free from gas till midnight on Sunday, the 22nd; the water-gauge, however, at this time shows a great discrepancy, or it may be an error in reading, for its readings vary down to 0·2 inch outbye pressure.

THIRD COMPARISON.

BETWEEN No. 3 WATER-GAUGE AND THE GAS-CHECK.

FIRST INSTANCE.

No. 3 water-gauge reads —0·6 inch on Saturday, the 5th of February, at 9 a.m., at the same hour the gas-check shows the place free from gas. On Sunday, the 6th, at 10 p.m., the water-gauge reads —0·6 inch, at the

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same hour gas comes off freely, as shown by gas-check, and continues to come off till Tuesday, the 8th, at 3 p.m., when the water-gauge reads —0·6 inch at the same time; the place is free from gas on Wednesday, the 9th, at 9 a.m., the water-gauge at 10 a.m. same day registers —0·6 inch. Gas comes away freely, and the place is not again free from gas till Thursday, the 10th, at 8 p.m.; the water-gauge registering —0·6 inch at 7 p.m. same day; the place remains free from gas till Saturday, the 12th, at 5 p.m., the water-gauge registering —0·6 inch three hours before; then the atmospheric pressure decreasing, gas comes away.

SECOND INSTANCE.

At 9 p.m. on Monday, the 21st of March, the water-gauge registers —0·6 inch, the gas-check at the time showing also the place to be free from gas; the place does not again appear free from gas till Friday, the 25th, at 9 a.m., the water-gauge at the same hour registering —0·6 inch. By the gas-check the place remains free from gas till Saturday, the 26th, at 5 a.m., when it shows for four hours, the water-gauge at the same time shows a slight increase of outbye pressure for a similar period; the place is again free from gas at 9 a.m. the same day, the water-gauge registering —0·6 inch at the same hour; the gas-check shows gas coming off at 10 p.m. the same day, the water-gauge registering at the same hour —0·5 inch. By the gas-check the place is free from gas on Sunday, the 27th, at 7 a.m., and remains so till 9 a.m., or for two hours. In this instance there is a slight discrepancy between the gas-check and the water-gauge, for the water-gauge registering —0·6 inch would indicate absence of gas for about a similar period, but two hours previously.

THIRD INSTANCE.

The gas-check shows the presence of gas up to Monday, the 16th of May, at 8 a.m., the water-gauge registering —0·6 inch at 6 a.m. the same day, or two hours before; the place remains free from gas by the gas-check till Tuesday, the 17th, at 1 a.m., the water-gauge then registering—0·5 inch. Gas again shows in the place till Thursday, the 19th, at 6 p.m., the water-gauge then registering —0·5 inch. The gas-check next shows the place free from gas on Friday, the 20th, at 5 a.m.; the water-gauge reading —0·6 inch at the same hour. The gas-check shows a trace of gas on Sunday, the 22nd, at noon, the water-gauge reading —0·6 inch at the same hour. Gas is present till 5 p.m. the same day, when the place is again free from gas; the water-gauge reading —0·6 inch. The place remains free from gas till midnight, the water-gauge during that period continuing to register —0·6 inch, and at that hour it works simultaneously with the gas-check.

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FOURTH COMPARISON.

BETWEEN No. 3 BAROMETER AND THE GAS-CHECK.

FIRST INSTANCE.

The barometer commences to rise at 1 p.m. on the 5th, and shows no depression till Monday, the 7th of February, at 4 a.m.—the gas-check shows no gas at 9 a.m. on the 5th, or four hours before the barometer commences to rise. Gas again shows on Sunday, the 6th, at 10 p.m., or six hours before a fall is denoted by the barometer, this fall continues and no rise of the barometer is shown till 11 a.m. on the 8th; the gas-check shows the place free from gas the same day at 3 p.m., the barometer therefore moves upwards four hours before the place is free from gas. Taking the barometer readings at 9 a.m. on the 5th, at 10 p.m. on the 6th, and at 3 p.m. on the 8th, there are three readings when there is no gas, and the barometer reads 30·95 inches, 31·8 inches, and 30·7 inches, respectively, at those periods. The barometer rises from Tuesday, the 8th, at 11 a.m., and shows no depression till 6 p.m. next day; the gas-check, however, shows gas to commence coming off on Wednesday, the 9th, at 9 a m., the fall of the barometer therefore is only apparent nine hours after gas has been detected. The gas-check shows presence of gas till Thursday, the 10th, at 8 p.m., the barometer commencing to rise at 9 p.m. on the same day, virtually at the same time. Taking two readings, namely, 9 a.m. on the 9th, and 8 p.m. on the 10th, there are two periods showing no gas and the barometer reading 31·4 and 30·4 inches respectively. The barometer rises from Thursday, the 10th, at 9 p.m., and shows no depression till Sunday, the 13th, at 3 a.m., but by the gas-check, gas comes off on Saturday, the 12th, at 5 p.m., or ten hours before the barometer commences to show the slightest fall, and that instrument continues steady for a considerable period; gas, nevertheless, is present in the gas-check; the barometer registers 31·75 inches at 5 p.m. on the 12th. There are therefore several periods when the gas-check shows no gas, the barometer readings recording:—

	Inches.
On the 5th of February	30·95
„ 6th „	31·80
„ 8th „	30·70
„ 9th „	31·40
„ 10th „	30·40
, 12th „	31·75

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SECOND INSTANCE.

The barometer had been very steady for some days, during which time the gas check had registered the place to be giving off gas at various times, also to be free from gas when a slight rise commenced on Monday, the 21st of March, at 9 p.m.; at the same hour the gas-check is free from gas for a short time, after which gas comes away and the place is not again free from gas till Friday, the 25th, at 9 a.m.; the barometer in this instance appears to be no certain guide, for commencing with the rise on Monday, the 21st, at 9 p.m., it continues to rise slightly for about twenty-four hours, gas coming off the whole time; after the twenty-four hours there is a sharpish fall for about twenty-seven hours, then a steady barometer for about twenty-nine hours, a rise commencing on Friday, the 25th, at 5 a.m., during the whole of this time gas is being given off; the gas check shows the place free from gas at 9 a.m. the same day, or four hours after the barometer commences to rise—the place is now free from gas for some time, the barometer continuing to rise. By the gas-check, gas comes off on Saturday, the 26th, at 5 a.m., when it shows for four hours, the barometer continuing to rise, and at this hour registering 31·30 inches. The gas-check is again free from gas at 9 a.m., the barometer registering 31·45 inches, and the place remains so till 10 p.m. same day, the barometer registering 31·65 inches. Gas shows at the gas-check till Sunday, the 27th, at 7 a.m., the barometer during the interval continuing steady, and reading 31·60 inches; the place remains free from gas for two hours, when it appears, the barometer nevertheless continuing steady, and registering about 31·60 inches for several hours after.

There are here five periods when the gas check shows no gas, the barometer recording:—

	Inches.
On the 21st March	31·30
„ 25th „	30·70
„ 25th „	31·45
„ 26th „	31·65
„ 27th „	31·60

THIRD INSTANCE.

The barometer marks a depression on Sunday, the 15th May, and no rise is shown till Monday, the 16th, at 6 a.m., when it goes up rapidly, the gas-check at the same hour showing the place free from gas, and it remains till Tuesday, the 17th, at 1 a.m., the barometer commencing to fall at 7 a.m. on the same day or six hours afterwards. After this there

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is rather a quick fall for about eleven hours, then a steady barometer for about sixty-two hours, during this time the gas-check shows the place free from gas for about two hours on Thursday, the 19th, the barometer not recognising this. The barometer commences to rise on Friday, the 20th, at 8 a.m., and continues rising up to Sunday, the 22nd, at 6 a.m. The gas-check shows no gas on Friday, the 20th, at 5 a.m., or three hours before the barometer commences to rise. During the period between Friday, the 20th, at 8 a.m., and midnight on Sunday, the 22nd, the barometer is steadily rising, and does not in any way recognise the presence of gas, as shown by the gas-check at about noon on the 22nd. At midnight on Sunday, the 22nd, the gas-check commences to show presence of gas, the barometer nevertheless continues high, and remains steady for a considerable time, in fact for about twenty-eight hours after gas appears, and then commences to fall slightly. There are thus five periods when the gas-check shows no gas, the barometer recording :—

	Inches.
On the 16th of May	30·65
„ 17th „	31·45
„ 19th „	31·00
„ 20th „	31·10
„ 22nd „	32·00

REMARKS ON COMPARISONS.

The first comparison made between the water-gauge and the barometer permits the following deductions to be made :—

1.—The extreme sensitiveness of the water-gauge in marking every fluctuation of atmospheric pressure on the gases in the sealed up workings.

2.—The great tardiness of the barometer in recognising these fluctuations.

It is apparent by the water-gauge diagram that fluctuations of gases in colliery workings must be occurring almost every hour, these frequent fluctuations seem to be clearly defined by the water-gauge whenever they take place, but they are not correspondingly recognised by the barometer, and it appears that the barometer only recognises what may be termed general or clearly defined great fluctuations, and even then very slowly. In several instances when the water-gauge has shown an inbye pressure prevailing, and the pressure having reached its limit, an outbye pressure commences, indicating that gas has commenced coming off, it is found that the barometer still continues to mark an upward tendency, as shown in

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the first instance, when the water-gauge commences to mark an outbye pressure at 5 p.m. on the 5th of February, this outbye pressure continuing till Monday, the 7th, at 6 p.m.; but the barometer at the beginning of this depression is actually rising, and shows no sign of a fall for thirty-four hours after the water-gauge, or four hours after gas actually shows in the gas-check. Again the water-gauge shows a depression, commencing at 7 p.m., on the 8th, and this depression continues till the 10th, at 2 a.m.; the barometer, however, at 7 p.m., on the 8th, is rising and continues to rise for some time and shows no depression till 6 p.m., on the 9th, which is twenty-three hours after the water-gauge shows the depression arriving, and nine hours after the gas actually shows in the gas-check. It is perhaps unnecessary to particularise these instances further, but other comparisons only tend to confirm and carry out the fact of the tardiness of the barometer in denoting the fluctuations of atmospheric pressures.

THE SECOND COMPARISON.

If the readings of No. 2 water-gauge (placed where the intake air has a direct action on the instrument, and only at a distance of 126 yards from the bottom of No. 1 Pit) are considered, it will be found (generally) that when it registers an inbye pressure of between 0·7 and 1·00 inch, with a tendency of that pressure being increased (inbye), there is generally an absence of gas in the gas-check; on the other hand, when the pressure is outbye from the above readings, and that pressure is increased (outbye), then gas is being given off from the strata. This however, is not fully carried out, for it is sometimes found that the water-gauge registers as low as 0·3 inch when gas is absent.

THE THIRD COMPARISON

between No. 3 water-gauge and the gas-check tends to confirm the former comparison, but with greater accuracy. Here the return air acts upon the water-gauge, and it will be found, generally, that whenever that instrument registers an outbye pressure of 0·6 inch with a tendency of that pressure being decreased, there is an absence of gas; on the other hand, when it registers 0·6 inch pressure outbye with the tendency of that pressure being increased, gas is given off from the strata.

THE FOURTH COMPARISON

between the barometer and gas-check clearly indicates the unreliableness of the barometer. In a few cases it is seen to act before gas is found in the gas-check, but generally it is not a true indicator to mark the giving off

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of gas; and it is well known that gas is frequently found in colliery workings before any fall of the barometer commences. It may be urged that frequently the barometer and gas-check work together; and this is so to some extent, as particularly instanced between the 5th and 7th of February; at the same time, however, the water-gauge proves during part of this time that the pressure was outbye, whilst, had the barometer been consulted, an inbye pressure would have been indicated. In fact, the barometer, so far as an indication showing that gas may be expected, cannot be said to be reliable. Unlike the readings of the water-gauge, those of the barometer, showing absence of gas, are so widely different that it is impossible to assume any general rule as to when the presence of gas may be expected.

CONCLUDING REMARKS.

One lesson suggested by the foregoing water-gauge, barometer, and gas-check readings is, that as an instrument for the use of all connected with colliery operations, the water-gauge may be found to be preferable to the barometer; and that if a water-gauge is connected with a sealed up working, its readings indicate nearly accurately the giving off or otherwise of gas in a colliery, which the barometer fails to do.

If the above system of ascertaining when gas may be expected to be given off in mines can be further substantiated, and put into actual use at collieries, it will doubtless prove of much greater service than placing too much reliance on an instrument so uncertain in its action in indicating gas as the barometer.

Many other comparisons might be made, and the Council, in acceding to an expressed desire to have the whole of the valuable diagrams printed that had been prepared of the experiments, have placed it in the power of the members to multiply these comparisons to any length, and no doubt much valuable information may be obtained thereby.

The object of this paper is not to propose any decided theory, but simply to place before the members the results from a number of experiments which have been made at great cost and trouble.

These are perhaps the only series of readings published, that contain such a variety of information obtained at the same or nearly the same moment of time, and, therefore, the contribution may prove valuable if only for that circumstance.

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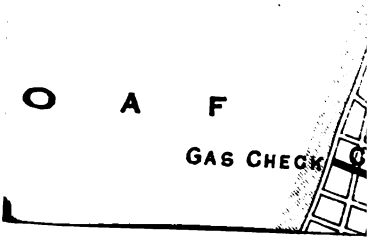

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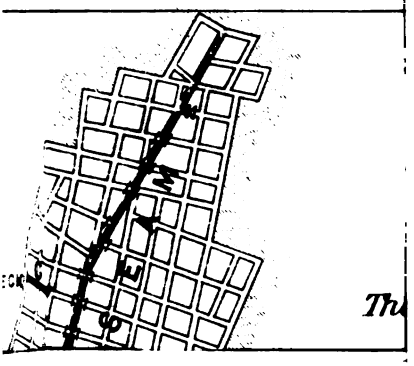

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The PRESIDENT said, it was a very interesting paper, and as it was intimately connected with another very valuable paper, namely, the one by Mr. Lindsay Wood "On the Pressure of Gas in the Solid Coal," it was desirable that the two questions should be discussed together.

Mr. J. DAGLISH said, he was sure the meeting was very much indebted to Mr. Corbett for the great pains and care he had taken in regard to the observations which he had so minutely laid before them, and also for the pains and care he had taken in analyzing the results of those observations, and in bringing before them so clearly the conclusions to which he had arrived. He might mention that many years ago he made a series of experiments at Hetton Collieries, with the view of ascertaining and recording the pressure of gas and the variations of the barometer; and the results he arrived at were precisely such as were given by Mr. Corbett, namely, that there was no connection whatever between the variations in the barometer and the prevalence of gas in the galleries of the mine; and that, as Mr. Corbett had shown them, the gas appeared so long before the barometer indicated any change that practically it was of no value; indeed, the gas had both come and disappeared before any variation in the atmosphere was recorded by the barometer.

Mr. LINDSAY WOOD thought there was a difference in principle between his paper and that by Mr. Corbett. The latter was a record of facts showing the pressure of gas in hermetically sealed working places of a mine, while his was a record of experiments showing the pressure of gas contained in the coal itself. The area of the workings which were sealed up in the Maudlin Seam were of a considerable extent, several hundred acres, whereas the pipe which connected these workings with the atmospheric air was of very small area, which all tended to make a most sensitive instrument for indicating any variation in the bulk of the gas or air contained in the large area of workings, the sensitiveness of which would be in direct proportion to the difference of the cubical contents of the bulk compared with the area of the pipe through which the bulk was connected with the atmosphere, and in this case the difference was enormous. The experiments which he (Mr. Wood) had made were undertaken for three purposes:—(1) To ascertain whether there was any relation between the issue of gas from the pores of the solid coal and the variations of the barometer; (2) to ascertain, if possible, what quantity of gas was being given off in different seams of coal per square foot of face exposed; and (3) to ascertain to what extent the issue of gas varied after certain periods of exposure of the surface of the coal. The results showed that there was no relation whatever between the varia-

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tions of the barometer and the temperature with the quantity of gas evolved; also that the places where the pressure of the gas in the coal had been highest did not seem to give off the greatest quantity of gas, and there appeared to be no connection whatever between the length of the hole and these quantities. In the experiment at Eppleton the hole was bored into the face of the coal 3 feet 6 inches, leaving only 18 inches of solid coal between the registering gauge and the space where the gas was allowed to accumulate; and yet the pressure reached 54½ lbs. With respect to the quantity of gas given out in the different seams of coal, it varied very considerably. In one case there was as much as six cubic feet of gas per hour per square foot of surface, whilst in another instance there was not more than from a half to three-quarters of a cubic foot per hour. Further experiments, however, were required to ascertain definitely the quantity of gas given off by a given area of a face of working coal, as the experiments in this case showed that it not only varied in the same hole, but varied during different hours in the same hole. In one case, at Eppleton, the quantity of gas coming from the coal increased after six days' exposure to 11·14 cubic feet per hour. After an exposure of five days the quantity given off increased rather than decreased, and after that it alternately increased and decreased, and it increased and decreased both with the rise and the fall of the barometer, showing that the barometer did not affect it in the slightest degree.

Mr. WILLIAM COCHRANE considered that the barometer was merely indicating the atmospheric changes, but the water-gauge was indicating the pressure inside the isolated workings. Probably the fire was not extinguished when the experiments were made, and they had no analyses of the gases. Therefore, there may have been outbursts of gas going on at the same time. In fact, the condition of things inside the supposed gasometer seemed to be so varying that he would not expect the barometer and the water-gauge to correspond. The greater sensitiveness of the water-gauge in indicating fluctuations of pressure, compared with the tardiness of the barometer, was due to the longer column of fluid used in the former.

Professor HERSCHEL said, the same comment as that made by Mr. Cochrane also arose in his mind when Mr. Corbett's paper was being read. It had occurred to him that the sealed-up chamber in which the water-gauge was registering the pressure, defined the pressure of a great mixture of gases as if they formed one single body; while in the galleries of the mine there was also a different collection of gases, of which the barometer showed the pressure as a single body; and the discharge of fire-damp out of the confined chamber would depend upon the pressure of the fire-damp

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which formed part of what the water-gauge indicated rather than upon the water-gauge pressure; and, as Mr. Cochrane had said, it would be necessary to have an analysis of the gases in the goaf so as to ascertain the fire-damp pressure there; and they would equally require to know the tension of fire-damp in the galleries of the mine. They could not expect the gas-check to copy or simulate exactly the changes of either the water-gauge or the barometer, but only the changes of pressure of fire-damp in the mine and in the goaf. Mr. Mallard, in his discussion of Mr. Wood's paper, had shown that the tension of fire-damp in the coal was the cause of its gas pressure quite independently of any atmospheric pressure, and the amount of fire-damp in the air was the question that had to be closely investigated. He thought that Mr. Wood's experiments were especially valuable as they had shown the pressure of fire-damp in the coal, and how gas would come out of the coal itself, by using gauges in which the interfering effects of air and other gases were excluded. Still there was no doubt they had an enormous accumulation of matter before them which would furnish them with plentiful results for further experiment and inquiry.

Mr. HENRY HALL (Inspector of Mines) said, that at the former discussion on Mr. Wood's paper the views of some of the members seemed to be that the very large pressure in the coal was due to a column of water, and that the amount of that pressure could be measured by the depth of the pit. But this seemed to be connected with a practical difficulty, because in Lancashire for instance, in the deepest seams, where there was a very great pressure of gas, the coal was perfectly dry and there was no water found at all. Could not this very high pressure be explained from the fact that, when the coal was forming and decay was taking place, and perhaps before that decay was complete, some impermeable strata were placed over the coal, and a great pressure was thus bottled up which corresponded to that found in the coal at the present time? With respect to the volume of gas issuing from the coal he thought it must depend on the nature of the coal. They found that in dangerous seams the gas comes out very rapidly, because the coal was open in its nature, and Mr. Wood's experiments seemed to show that the different seams varied very much in the quantity of gas given out, and that the dense seams appeared to give out the least amount of gas. With regard to the varying pressure which the gas exerted from time to time, he thought it would be found to be due to a varying atmospheric pressure. There was one other matter which he should like to mention. Mr. Wood had told them that, in one of his experiments, two feet from the face of

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the coal there was something like 54 lbs. of pressure on the square inch. He thought it was very important to consider the effect of common shots or blown-out shots under circumstances of that kind. If there was that immense pressure immediately behind the face of the coal there must be great danger if any vacuum was set up by a shot. With the view of testing the point he had made an experiment which had satisfied him of the danger he referred to. The experiment consisted of firing charges of gunpowder from a small cannon fixed at the end of a boiler 36 feet long and 6 feet diameter. It was found that a charge of half-a-pound of powder fired in this way showed, by Richard's indicator, a vacuum set up inside the boiler equal to from 2½ to 3 lbs. on the square inch, and this vacuum was set up not only at the end of the boiler close to the cannon, but also along its sides towards the exit ends. That was a very important matter, and he should be very glad if some of the members would give them some information on the point.

Mr. Wood said, Mr. Hall had thrown out the suggestion that the pressure due to a column of water should have been added to the experiments. Since the paper had been read and prior to it being printed that had been done, and the result was given in Table E., and he thought it proved that there was no connection between the pressure that was shown to exist in the coal and the pressure due to a column of water the height of the over-lying strata. In the experiment at Boldon the pressure due to a column of water was 549 lbs., and the pressure of gas varied from 17 lbs. to 461 lbs. He quite agreed with Mr. Hall that the extreme pressure of gas in the coal had no relation with the variations of the barometrical column and the temperature, but that such variations were most likely due to the formation of the gases, as already described, and not to any action of water, as the seams were perfectly dry. As to the pressure of the barometer being taken at the same time as the pressure of the gas in the holes, he submitted that was the proper time to take it, and not thirty-six hours before or after the variations occurred. It showed the actual pressure and the barometrical changes at the same time as the change of pressure was taking place in the bore-hole.

Mr. T. W. Bunning thought it was only right that he should point out the fact that the paper showed that the water-gauge was not placed anywhere near where the gas-check was placed. They would see that the gas coming out in the gas-check from the goaf, where there was no fire, was anticipated and recorded almost at the same time by the water-gauge in the other part of the pit, which was hermetically sealed. Therefore the simultaneousness of these two readings was, he thought, on that account very significant.

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Mr. A. L. STEAVENSON said, that Mr. Wood had observed in the concluding remarks to his paper that he hoped these experiments would lead to more elaborate research, and he thought he would forgive him (Mr. S.) when he said he had only just touched the fringe of the subject. It was really one to which a man might devote his whole lifetime. They had to consider the origin of gas in coal as well as the conditions under which it was found, and he would suggest that further experiments should be made to elucidate this subject. One direction of the research might be as to the natural flow of gas from the face of the strata without boring into it. In Mr. Wood's experiments it appeared that the face of the coal was covered up by an impervious coating of cement. That was very well so far as it went, but he thought the natural flow of gas from the face might be better tested by going up to some hitch where a natural barrier was found, and the pressure there would probably be much greater than where there was an artificial covering such as Mr. Wood had applied. It might also be tested by stopping a passage or a series of passages in the coal without boring into the coal at all. Probably by closing up some of the drifts and measuring they would get more accurately the natural flow of gas from the face. The questions raised by Mr. Wood were not merely connected with the amount of gas found in the coal itself, but also with such interesting subjects as blowers and outbursts. The outbursts of gas were much more prevalent in Yorkshire than in Durham, but he did not think that the pressure was higher in the former than in the latter county. He believed it was rather to be accounted for from the fact that in Yorkshire they adopted the long-wall system of working, whilst in Durham they practised the board and pillar system. Mr. Mallard seemed to agree with that view. He said—"In mines subject to this description of accident it would be most desirable to drive galleries deeply into the solid in advance of the working face and to make frequent measurements of the distribution of pressure, so as to check the advance of the workings when the rate of the increase of pressure exceeded a certain limit. This would be perhaps the most certain means of preventing these disastrous accidents." This was very much the view he (Mr. S.) enunciated in recommending the board and pillar system instead of the long-wall to prevent these sudden outbursts. Another highly important question to consider was as to whether it was not possible to render practically useful the large amount of gas which had been shown by Mr. Wood to be available in the coal itself. Before Mr. Wood's experiments they never realized the fact that the gas was under such very high pressure; and it was now worthy of consideration whether that gas

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could not be collected and used for the creation of mechanical power in the same way as gas was now used for gas engines. He pointed out that the greatest quantity of water was found at a depth of 100 fathoms, and he was inclined to think with Sir George Elliot, that the greatest quantity of gas would also be found at that depth. He had very great pleasure in recognising the value of Mr. Wood's contribution to their volumes, and he hoped the experiments made by Mr. Corbett and Mr. Wood would lead to further study and research, especially on the points he had mentioned.

Mr. COCHRANE considered that the suggested experiments to ascertain whether the gas pressure could be applied for the creation of mechanical power would be of very great value. He should like to ask Mr. Bell, who was a gentleman of much experience, whether the carburetted hydrogen gas in the strata was capable of being liquefied or solidified, to account for such extreme pressures as were to be found in outbursts?

Mr. ISAAC LOWTHIAN BELL replied that it would either be in a state of great tension as a gas or be in the form of liquid. He did not know what amount of pressure would be required, coupled with lowness of temperature, to produce liquidity of the hydro-carbons. If he remembered rightly, Mons. Caillé had stated that the hydro-carbons resisted all his attempts to reduce them to the liquid state.

Mr. COCHRANE asked Mr. Wood if he had tried the length of time at which the pressure of gas became exhausted?

Mr. WOOD replied that if the bore-hole was stopped up he imagined that the gas would accumulate until the pressure came to its original pressure in the coal. For twenty-two days there did not seem to be any decrease, or at all events very little decrease.

Mr. T. W. BUNNING drew the attention of the meeting to the concluding remarks in Mr. Mallard's paper:—"Questions as to the mode of existence and mode of disengagement of fire-damp have thus acquired a solid foundation, upon which further experimenters can build a more perfect theory. It would seem that the most useful thing to do now is to determine, by experiments, the value of the co-efficients designated by the letters k_0 and a for a number of mines; that is, the volume of gas given off per unit of surface at the face at any time, and the co-efficient of the permeability of the coal for the gas. These are the two data which constantly regulate, with the maximum pressure in the solid coal, the disengagement of gas." If these points were solved with any degree of authority it would throw a vast light on the quantity of gas occurring in different pits under different circumstances and modes of working.

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Professor HERSCHEL thought it would also be desirable to determine the capacity of coal for gas in just the same way as it is usual to determine the capacity of a substance for heat. Mr. Mallard had shown so clearly (at page 125 of the translation of his paper in these Transactions, and in the following tables of figures, in which the results of Mr. Wood's experiments were discussed) that the relations of gas-flow and pressure in a solid face of coal are exactly those of the thermal conduction and temperature in a mass of unequally hot rock or other substance, that, had the simplicity of this relation occurred to him, on reading the translation of Mr. Mallard's paper, as really founded, as it no doubt is, in a natural and not merely in a conjectural resemblance between the modes of occupation of solid bodies by gas and by heat, he would have easily devised, and would by this time have made, some experimental measurements in the directions pointed out by the concluding words of Mr. Mallard's paper. A determination of coal's gas-capacity or co-efficient of absorption for fire-damp at different pressures would answer Mr. Cochrane's question as to the state in which the gas exists in the coal at high tensions by showing what quantity and what weight of gas were contained in a given bulk of coal at a given gas pressure of its absorptive fixation or confinement there. It was a point not mentioned in the closing paragraph of Mr. Mallard's paper, which, like the other data which he mentions, it would also be of great practical importance to determine experimentally if possible.

The PRESIDENT said, the time had now arrived to close the discussion for the present, and he begged to propose a vote of thanks to Mr. Corbett and Mr. Wood for their attendance and papers. One of the chief points of discussion had been as to whether they were to depend upon their old friend the barometer to give them warning of danger in time for safety. To a very great extent Mr. Wood's paper seemed to have disposed of that question as far as regarded the pressure of gas from the solid coal, and Mr. Corbett's paper as far as the pressure of gas from the goaf was concerned. Mr. Wood had advocated the finding, if possible, of a barometer more sensitive than one of mercury. Such a one, he believed, was in use at the Naworth Collieries.

The meeting was then adjourned until the next day, and the members proceeded by special train to inspect the works belonging to the Barrow Hæmatite Steel Company, after which they returned to the Market Hall where they were entertained at luncheon by the Directors of the Company.

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The following works and mines were thrown open to the members during the week:—

The Shipbuilding and Engineering Works belonging to the Barrow Shipbuilding Company.

The extensive New Docks of the Furness Railway Company.

The Jute Works of the Barrow Flax and Jute Company.

The Engineering Works of Messrs. Westray, Copeland, and Company.

The Shipbuilding Works of Messrs. Caird, Purdie, and Company.

The Steel Wire Works of Messrs. Cookes and Swinnerton.

The Iron Works of the North Lonsdale Iron and Steel Company at Ulverston.

The Boiler, Bridge, and Girder Works of Messrs. Woodall, Marley, and Company.

The Foundry and Engineering Works of Messrs. Waddington and Longbottom.

The Saw Mills and Brick Works belonging to the Executors of the late Mr. William Gradwell.

The North Lancashire Patent Machine Brick and Tile Works of Messrs. B. Carruthers and Company.

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PROCEEDINGS.

ADJOURNED GENERAL MEETING, JULY 4TH, 1883, IN THE TOWN HALL, BARROW-IN-FURNESS.

GEORGE BAKER FORSTER, ESQ., IN THE CHAIR.

The members assembled at ten o'clock, and the following paper was read:—

THE STRUCTURE OF THE CUMBERLAND COAL-FIELD.

BY J. D. KENDALL, C.E., F.G.S.

ALTHOUGH this field has been worked extensively, and for a very long time, yet comparatively little has been made known to the public regarding either its extent or the number and the nature of the seams found in its different parts. Mr. Dunn's Paper "On the Coal-fields of Cumberland," printed in the Transactions of this Institute,* is the most extensive contribution to the subject that has yet been made; but it is only short, and relates more especially to the "probability of coal being found under the New Red Sandstone which surrounds the city of Carlisle." A little information is also given in "An Account of the Coal Mines near Whitehaven," by Joshua Dixon, but it extends only to the Whitehaven Colliery. The dearth of available information generally is fairly shown by the meagre notice that the field has received in Hull's "Coal-fields of Great Britain," where all that is said on the Cumberland coal-field occupies about three pages only. Not merely among outsiders, but also on the

* Vol. VIII., pp. 141-154.

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coal-field itself is this want of knowledge felt, so that, it is hoped, the present attempt to initiate a different state of things may not be unacceptable to the members of this Institute.

POSITION AND EXTENT.

A few years ago a borehole was put down at St. Bees, which proved the coal-field to exist there, but it has not yet been found to the south of that place. From St. Bees northwards to Maryport, the Coal-measures may be said to extend inland for an average distance of about 4½ miles. They also lie under the sea between those points, but for what distance is unknown, although at Whitehaven they have been worked seaward for about two miles from the coast.* At Maryport the coal-field, so far as it is known, leaves the coast and extends inland, its northern boundary passing near Aspatria and High Blaithwaite, in the parish of Bolton. In passing north-eastward from Maryport, the coal-field becomes gradually narrower on to Gilcrux, where it is only 1¾ miles wide. Thence widening a little it continues in nearly a straight line to Bolton New Houses. There the field for practical purposes may be said to terminate, for although the Coal-measures extend to Rose Castle, yet, so far as is at present known, this extension does not contain any important seam of coal, and therefore it will only be very generally dealt with in this investigation. The extent of the coal-field is known only approximately for two reasons:—

1.—Part of it is covered by the sea, and cannot therefore be seen.

2.—Part of it is also covered by Permian rocks of such a thickness that they have not yet been pierced, so that the extent of Coal-measures under those rocks is at present a matter of mere conjecture.

The area of that portion of the coal-field which is known, and which lies between Bolton Low Houses and St. Bees, exclusive of the coal under the sea, is about 91 square miles, its length being about 28 miles, and its greatest breadth 6 miles.

RELATION TO OTHER FORMATIONS.

The basement rocks of the district are of the Silurian age, and they consist of two formations:—

1.—Volcanic Series of Borrowdale.
2.—Skiddaw Slates. } Silurians.

* Report of Coal Commission, Vol. II., 1871.

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These Silurians are surmounted transgressively by rocks of Carboniferous age, which, among other formations, include the Coal-measures, as shown below.

1.—Coal-measures.
2.—Millstone Grit.
3.—Carboniferous Limestone, reposing on Silurians.
} Carboniferous System.

These three formations, with the exception of the upper part of the Coal-measures, are conformable to one another.

Overlying the Carboniferous System are the Permians, which include three formations:—

1.—St. Bees Sandstone.
2.—Magnesian Limestone.
3.—Breccia.
} Permian System.

The various members of the Permians are quite conformable to one another, but they are unconformable to the Carboniferous rocks, as is shown by the Breccia at different times reposing upon each of the three members of the Carboniferous rocks.

The chief features of all these rocks were described by the author in his paper "On the Hæmatite Deposits of West Cumberland," published in the Transactions of the Institute,* and therefore it is unnecessary to notice them again here.

The areas occupied by each of these systems in the neighbourhood of the coal-field are shown in Fig. 1, Plate XXXII. Fig. 2 in the same plate exhibits a generalized section through the district, for the purpose of making clear the relations of the three rock systems to one another.

STRATIGRAPHICAL CONFORMATION.

The position of the Coal-measures vertically with reference to other formations being established, it will be necessary now to consider somewhat exhaustively their character and constitution.

Naturally, the Coal-measures are divisible into two parts, namely:—

1.—Whitehaven Sandstone, or Upper Coal-measures.
2.—Lower Coal-measures (reposing on Millstone Grit).

The Whitehaven Sandstone is unconformable to the Lower Coal-measures, and on that account it was formerly considered to belong to the Permians; but there is now no doubt about its Carboniferous age. As will presently appear, it contains several seams of coal, some of which have been extensively worked in different parts of the district.

* Vol. XXVIII., p. 109.

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To arrive at a correct idea of the relation of the Whitehaven Sandstone to the Lower Coal-measures, it is necessary to correlate the seams of coal found in these latter measures in different parts of the district where the Whitehaven Sandstone occurs. This will now be done, and, that the comparison may be made as complete as possible, the detailed results of a number of sinkings and borings in various parts of the district will be given. The position of the several pits, of which sections will be given, are shown in Fig. 1, Plate XXXII.

The Lower Coal-measures consist mainly of sandstone and shales, the remainder of the mass being made up of coal and ironstone. The prevailing colours of the sandstone are white, sometimes streaked with black, and bluish grey. The shales are light grey, bluish grey, and black. In the following journals there are a number of local names used, which it may be well to explain here, as otherwise the journals would lose much of their value.

Local Names of Argillaceous Rocks.

Sill or *thill* means fire-clay. The word thill is also sometimes applied to the floor of the mine, irrespective of the kind of material occurring below a coal seam.

Caum, comb, or coam.—Sandy shale. When the word "stone" is used in conjunction with any of these words, as "stone comb" or "comb stone," it implies a degree of hardness approaching that of sandstone.

Metal and metal stone.—Shale; the latter being hard and stone-like.

Tom.—Hard bituminous shale, sometimes sandy and micaceous, occurring in some coal seams, and having occasionally thin layers of coal in it. The use of this word is restricted to Dearham, Maryport, Greysouthen, and Broughton Moor.

Scram.—Black shale, with thin layers of coal running through it. It occurs at the bottom of some of the coal seams. This expression is mostly confined to the same district as "Tom."

Cash.—Soft black shale in very thin small pieces lacking coherence; can be crushed between the fingers into a powder.

Rattler.—A very bituminous shale.

Local Names of Siliceous Rocks.

Post.—Sandstone, usually hard.

Grey Beds.—Whitish sandstone streaked and spotted with black.

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SECTION OF WHINNYHILL PIT, CLEATOR MOOR.

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Red clay	13 2 0	
Gravel and water ...	4 4 0	
Red freestone, jointy and watery ...	15 4 0	
Freestone sill, red and soft	1 2 0	
Coal sill	1 0 0	
Red caum	3 2 0	
Grey freestone ...	3 3 0	
Blue caum, tinged red	2 0 0	
Grey metal stone ...	0 4 0	
Red caum	0 2 0	
Red and blue caum ...	2 5 0	
COAL (1st), three partings, 1 ft. 4 in. of blue metal ...	1 0 0	
		49 4 0
Strong grey sill ...	0 5 0	
Grey randed stone ...	0 5 0	
COAL (2nd) ...	0 2 2	
		2 0 2
Dark sill	0 4 6	
Dark randed stone ...	0 5 2	
Black metal stone ...	3 0 0	
Black caum	1 2 7	
Black caum, catscope and spar	0 0 5	
COAL (3rd) ...	0 1 5	
		6 2 1
Strong grey sill ...	3 3 0	
White freestone ...	0 2 0	
Dark grey freestone	1 1 0	
Blue caum and catscope	1 0 0	
COAL (4th) ...	0 1 4	
		6 1 4
Sill	1 1 0	
Light caum	0 4 0	
COAL (5th) ...	0 0 8	
Sill	0 0 6	
Randed caum ...	5 3 0	
COAL (6th)—*Six-feet Band*	1 0 4	
		8 3 6
Stone sill	0 3 0	
Randed caum, dark, with little freestone	4 0 0	
Randed caum ...	0 3 0	
Cash and catscopes ...	0 1 3	
COAL (7th)—*Four-feet Band*	0 4 5	
		5 5 8
Sill	0 1 0	
White freestone, soft parting	1 0 0	
Dark caum	0 3 0	
COAL (8th) ...	0 0 1½	
Dark caum	4 2 0	
Black metal	0 0 8	
Strong red caum ...	2 3 10	
COAL (9th)—*Fire-feet Band*	1 0 0	
		9 4 7½
Coal metal	0 3 0	
COAL (10th) ...	0 0 4	
Sill	0 0 6	
Caum, upper part randed	3 3 0	
White freestone ...	1 0 0	
Caum	0 2 0	
Rattler	0 0 6	
COAL (11th)—*Bannock Band* ...	1 2 4	
		6 5 8
Sill	1 0 0	
Cash	0 1 0	
COAL (12th) ...	0 1 0	
		1 2 0
Sill and caum ...	0 2 0	
Caum, with white freestone	1 2 0	
Freestone	14 0 0	
Grey metal	0 5 0	
COAL (13th)—*Main Band*	1 3 0	
		18 0 0

SECTION BELOW MAIN BAND, No. 2 PIT, CLEATOR MOOR.

	Fs. Ft. In.	Fs. Ft. In.
COAL—*Main Band*		1 2 9
Sill	0 5 0	
White post	0 4 0	
Shales, with thin ironstone	2 5 6	
COAL	0 0 6	
Sill	0 1 6	
Ironstone	0 0 2	
Shales	0 5 0	
Ironstone	0 0 3	
Carried forward	5 3 11	

	Fs. Ft. In.	Fs. Ft. In.
Brought forward	5 3 11	
Shales	1 1 2	
COAL, coarse cannel	0 1 10	
		7 0 11
Shales	0 1 8	
Mussel band	0 2 2	
Ironstone	0 0 1½	
Shales	0 2 0	
Ironstone	0 0 2¼	
Shales	0 1 0	
Ironstone	0 0 2½	
Carried forward	1 1 4½	

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SECTION BELOW MAIN BAND, No. 2 PIT, CLEATOR MOOR.—*Continued.*

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	1 1 4½	
Shales	0 0 10	
COAL—*Yard Band*	0 3 0	
		1 5 2½
Sill	0 1 4	
Caum	2 3 0	
COAL	0 0 8	
Soft metal	0 1 9	
COAL, bad ...	0 1 0	
		3 1 9
Sill	0 2 3	
Caum metal ...	1 4 2	
COAL	0 0 6	
Hard sill	0 5 1	
Dark freestone ...	1 5 0	
Randed freestone ...	2 3 10	
White freestone ...	0 4 6	
COAL	0 1 4	
		8 2 8
Sill	0 3 2	
Dark freestone ...	3 0 0	
Caum	2 2 0	
Rattler	0 0 6	
COAL	0 2 4	
		6 2 0

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Sill	0 4 6	
Randed caum metal	2 4 8	
COAL, cannel ...	0 1 0	
COAL, bad ...	0 1 8	
COAL, cannel ...	0 0 11	
Soft metal	0 0 7	
COAL	0 1 6	
		4 2 10
Sill	0 3 6	
Randed caum ...	3 1 0	
...	0 0 10	
Caum metal... ...	0 1 0	
COAL	0 1 10	
		4 2 2
Sill	0 2 6	
Caum metal... ...	0 3 6	
Black metal ...	0 5 0	
COAL	0 1 0	
		2 0 0
Grey shale	0 2 6	
Dark metal	0 2 0	
COAL—*Low Bottom Band* (*Six-quarters* at Whitehaven)	0 3 0	
		1 1 6

SECTION OF CROFT PIT, WHITEHAVEN, ABOVE BANNOCK BAND.

	Fs. Ft. In.	Fs. Ft. In.
Soil	0 1 3	
Soil and clay mixed ...	0 4 9	
Black sill	0 1 0	
Brown soft limestone, resembling stone marl in irregular strata	1 3 0	
Dark coloured limestone, harder ...	1 0 0	
Yellowish limestone, mixed with spar ...	0 4 0	
Reddish hard limestone	0 2 0	
Reddish hard limestone, with finer particles	0 1 6	
Hard, dark-coloured limestone	0 1 4	
Yellowish limestone, mixed with spar ...	0 4 0	
Soft brown limestone	0 4 2	
Soft brown and yellow limestone, mixed with freestone ...	0 2 6	
Limestone, mixed with yellow freestone ...	0 2 0	
Reddish soft freestone	0 1 6	
Red slate, striated with freestone in thin layers	0 2 6	
Carried forward	7 5 6	

	Fs. Ft. In.	Fs. Ft. In.
Brought forward	7 5 6	
Red freestone ...	7 0 6	
Soft red slate ...	0 0 6	
Red slate, striated with red freestone in thin layers... ...	4 1 0	
Red slate, striated with freestone	4 3 0	
Strong red freestone, rather greyish ...	4 5 9	
Lumpy red freestone, speckled with white freestone	0 0 9	
Blue argillaceous schistus, speckled with *coal*	0 0 9	
Red soapy slate ...	2 1 0	
Black slate, with a small appearance of *coal* under it ...	0 1 0	
Ash-coloured friable argillaceous schistus	0 4 0	
Purple-coloured slate, striated with freestone	3 5 3	
The same, and under black slate... ...	0 4 0	
COAL	0 1 0	
		36 4 0

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SECTION OF CROFT PIT, WHITEHAVEN, ABOVE BANNOCK BAND.—*Continued.*

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Soft whitish freestone	1 4 2	
Blackish slate, a little inclined to brown...	0 4 11	
COAL	0 1 10	
		2 4 11
Blackish slate, intermixed with *coal* ...	0 2 6	
Whitish freestone ...	1 2 6	
Strong bluish slate, mixed with grey freestone	0 3 0	
White ironstone ...	0 1 0	
Freestone, striated with blue slate	0 1 8	
Freestone, striated with blue slate in thin layers	1 3 3	
Dark blue slate ...	2 1 6	
COAL	0 0 9	
Dark grey slate ...	2 3 8	
COAL, with slate 1 inch thick	0 2 0	
		9 3 10
Grey freestone, mixed with ironstone ...	1 2 0	
Hard white freestone	2 3 6	
COAL	0 1 1	
		4 0 7
Shale, mixed with freestone	1 2 0	
Olive-coloured slate, adhering to black...	0 2 4	
COAL	0 1 1	
		1 5 5
Black shale, mixed with freestone ...	1 2 8	
White freestone, mixed with slate	1 2 0	
Dark blue slate ...	3 4 4	
COAL	0 1 3	
		6 4 3
Black shale, mixed with freestone	1 1 6	
Strong white freestone	1 0 0	
Brown ironstone ...	0 3 0	
Dark grey slate ...	1 0 0	
Dark grey shale, with an intermixture of *coal* about 5 in. thick	0 5 6	
Light-coloured slate, mixed with freestone	0 5 6	
Blue slate, striated with freestone ...	1 4 0	
Strong white freestone, a little tinged with iron	0 2 6	
Very black shivery slate	1 4 3	
COAL, strong and of good quality ...	0 0 4	
Carried forward	9 2 7	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	9 2 7	
Soft grey slate ...	0 0 3	
COAL, very black, burns well... ...	0 0 8	
Hard black shale ...	0 1 7	
COAL, mixed with pyrites	0 1 2	
		10 0 3
Argillaceous schistus, grey and brittle ...	0 3 0	
Blue rough argillaceous schistus ...	0 4 6	
Fine blue slate ...	0 3 0	
Freestone, mixed with ironstone	0 3 0	
Black shivery slate ...	1 0 0	
Dark blue slate, very fine	0 5 6	
Dark blue slate, very brittle	0 0 6	
COAL	0 2 6	
		4 4 0
Soft grey argillaceous schistus	0 0 6	
Argillaceous schistus, mixed with freestone	0 2 0	
White freestone, with fine particles ...	1 1 0	
Blue slate, striated with white freestone	0 4 7	
Light blue slate, very fine	0 3 0	
Blue slate, a little mixed with ironstone	2 0 0	
Black shivery slate ...	0 1 0	
COAL	0 0 6	
Brownish hard slate...	1 3 0	
Strong blue slate, tinged with ironstone ...	4 4 6	
Dark blue slate, rather inclined to brown and brittle... ...	0 1 6	
Blue soft brittle slate	0 0 6	
COAL	0 1 0	
		11 5 1
Lightish grey argillaceous schistus, brittle and soapy	0 4 0	
Freestone, striated with blue slate	1 1 0	
Fine blue argillaceous schistus, striated with white freestone	0 4 0	
Black slate, with hard, sharp and fine particles	0 3 0	
Blue slate, light and fine...	4 3 0	
COAL — *Bannock Band*	0 5 4	
		8 2 4

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Section below Bannock Band, Wellington Pit, Whitehaven.

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
COAL — *Bannock Band*		0 8 5
Sill	2 3 0	
Caum metal	4 0 0	
Randed caum ...	6 4 0	
Post, randed with caum	7 0 0	
COAL—*Main Band*	0 10 7	
		21 5 7
Sill ... 0 2 0		
Caum metal 3 3 0		
	3 5 0	
Soft metal	0 1 1	
COAL, little ...	0 0 8	
Hard dark sill ...	0 2 3	
Randed caum ...	1 4 0	
COAL, cannel ...	0 1 5	
		6 2 5
Soft grey shale ...	0 0 2	
Caum	1 1 1	
COAL, cannel ...	0 0 5	
Strong sill	0 1 7	
Freestone	0 5 4	
Caum	1 4 2	
COAL, little ...	0 0 8	
Sill	0 0 10	
Caum	1 5 6	
Metal	0 0 10	
COAL and thill ...	0 2 8	
		6 5 3
Hard sill	0 1 4	
Caum	2 3 0	
COAL	0 0 8	
Soft metal	0 1 9	
COAL, bad	0 0 11	
Sill	0 2 2	
Caum	1 4 2	
COAL	0 0 6	
Hard sill	0 5 1	
Dark freestone ...	1 5 0	
Randed caum ...	2 3 10	
White freestone ...	0 4 6	
COAL and thill ...	0 1 2	
		11 4 1
Soft sill	0 3 2	
Dark freestone ...	3 0 0	
Caum	2 2 0	
Rattler	0 0 6	
COAL	0 2 0	
		6 1 8
Hard sill	0 4 6	
Randed caum ...	2 4 8	
COAL, cannel ...	0 1 0	
COAL, bad	0 1 8	
COAL, cannel ...	0 0 11	
Soft metal	0 0 7	
COAL	0 1 4	
		4 2 8
Metal	0 0 4	
Soft sill	0 3 5	
Randed caum and cats-copes	3 1 0	
Ironstone	0 0 10	
Randed caum ...	0 1 0	
COAL	0 1 8	
		4 2 3
Sill	0 2 6	
Black caum metal ...	0 3 6	
Ironstone	0 0 7	
Black caum metal ...	0 0 11	
COAL	0 1 0	
		1 2 6
Dark metal	0 2 0	
Soft grey shale ...	0 0 6	
Dark metal	0 1 10	
COAL—*Six-quarters Band*	0 7 7	
		1 5 11
Metal	0 0 3	
Sill	0 1 0	
COAL	0 0 4	
Soft grey shale ...	0 0 3	
Sill	0 2 0	
Randed caum ...	1 3 6	
Soft grey shale ...	0 0 3	
COAL	0 1 9	
		2 3 4
Randed caum ...	1 0 8	

Skeleton Section of Borehole put down in Wellington Pit, Whitehaven, below Six-Quarters Coal.

	Fs. Ft. In.	Fs. Ft. In.
COAL—*Six-quarters*		
COAL seam ...	0 1 0	15 0 0
COAL seam ...	0 1 3	5 0 0
COAL seam ...	0 3 5	27 0 0

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SKELETON SECTION OF SEAMS AS DETERMINED BY JOHN PIT, HARRINGTON.

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
COAL—*Metal Band*	0 1 8	
COAL—*Two-feet* ...	0 1 10	15 0 0
COAL—*Three-feet*...	0 2 8	17 0 0
COAL—*Four-feet* ...	0 3 4	38 0 0
COAL—*Udale or Five-feet*	0 4 0	28 0 0
Carboniferous limestone (top of) 30 fms. below *Udale Seam.*		

This pit passed through a large fault below the three-feet coal as shown on Section 1, Plate III., but the above section was arrived at by making allowance for this fault. The actual depth to the top of the limestone in the shaft was 100 fathoms, and the total depth of the pit 110 fathoms.

SECTION OF JOHN PIT, WORKINGTON, TO MAIN BAND.

	Fs.	Ft.	In.	Fs.	Ft.	In.
Gravel	5	0	0			
Hard clay, mixed with stone	3	5	0			
Soft metal	1	1	0			
COAL, soft... ...	0	0	4			
Sill and soft metal ...	1	3	8			
Stone comb, with thin beds of stone ...	3	2	0			
Blue metal	1	2	0			
COAL, hard brassy	0	1	6			
				16	3	6
Hard stone sill ...	0	4	6			
Stone caum	9	3	0			
Very black metal ...	0	4	0			
COAL—*Brassy Band*	0	3	0			
				11	2	6
Sill	0	3	0			
Stone caum, with some beds of stone ...	10	5	8			
COAL—*Cannel Band*	0	3	4			
				12	0	0
Stone caum, with blue metal	7	3	8			
COAL—*Metal Band*	0	3	4			
				8	1	0
Strong blue caum ...	6	4	0			
COAL—*Fiery Band*	0	1	6			
				6	5	6
Strong blue caum ...	3	1	0			
Banded stone ...	0	3	0			
Blue caum	0	5	0			
COAL—*Moor Banks Band*	0	2	6			
				4	5	6
Blue caum	4	1	6			
COAL—*Little Main Band*	0	1	6			
				4	3	0
Stone caum, with stone beds	17	3	0			
Strong hard brown stone	2	3	0			
COAL	0	0	4			
Stone caum, with stone	4	5	8			
White stone	2	0	0			
White stone, mixed with *coal pipes* (position of *Main Band*)	0	3	0			
				27	3	0

SECTION OF HENRY PIT, WORKINGTON, BELOW MAIN BAND.

	Fs.	Ft.	In.	Fs.	Ft	In.
COAL—*Main Band*				1	4	0
Sill	2	3	0			
Stone...	2	3	0			
COAL	0	0	6			
				5	0	6
Sill	1	0	0			
Stone	1	3	0			
Metalline, or caum ...	1	4	0			
Stone	1	3	0			
Metalline	1	3	0			
Carried forward	7	1	0			
Brought forward	7	1	0			
Stone	1	0	0			
Metal...	2	0	6			
COAL and metal ...	0	1	6			
				10	3	0
Sill	0	5	0			
White stone	1	1	0			
Metalline, or caum, with stone beds ...	10	0	0			
COAL, clean ...	0	1	6			
				12	1	6

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SECTION OF HENRY PIT, WORKINGTON, BELOW MAIN BAND.—*Continued.*

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Blue metalline, or sill	1 0 0	
Blue metalline, with beds of stone ...	6 2 0	
Black metal	0 2 6	
COAL—*Yard Band*	0 2 8	
		8 1 2
Sill	1 1 0	
Black metalline ...	2 3 0	
COAL	0 1 3	
		3 5 3
Sill	0 4 0	
COAL	0 0 10	
Stone	0 5 0	
Stone metalline, or caum	10 3 0	
COAL—*Hamilton Band*	0 2 9	
		12 3 7

SECTION OF MILLBANK PIT, GREYSOUTHEN, BETWEEN TEN-QUARTERS AND CANNEL BAND.

	Fs. Ft. In.	Fs. Ft. In.
COAL—*Ten-quarters*		0 4 0
Sill, very full of black stripes	0 4 0	
Soft parting	0 0 2	
Hard parting ...	0 0 4	
Freestone	0 1 0	
Partings	0 0 6	
Freestone	0 2 0	
Blue sill	0 3 0	
Ironstone and catscope bed...	0 0 2	
Blue sill, or more of the nature of soapy grey beds	1 4 6	
Catscope beds ...	0 0 2	
Blue sill, or more of the nature of soapy grey beds	0 0 6	
Soft parting of a dark colour	0 0 6	
Black sill	0 0 10	
Rattler COAL *Rattler Band*	0 0 8 0 1 4	
		4 1 8
Sill, full of black stripes	0 1 6	
White comb	0 5 0	
Catscope bed... ...	0 0 2	
Freestone three-poster	1 0 0	
Comb and freestone mixed	2 1 0	
Parting soft sill ...	0 0 6	
Black metal resembling slate	0 4 0	
COAL	0 0 6	
Sill	0 0 8	
Catscope bed... ...	0 1 0	
Black metal resembling cannel	0 1 6	
COAL	0 0 7	
Sill and blue metal ...	0 3 6	
Hard freestone, or ironstone, or bastard limestone	0 1 0	
Carried forward	6 2 11	

	Fs. Ft. In.	Fs. Ft. In.
Brought forward	6 2 11	
Strong grey metal ...	1 3 0	
Strong dark metal ...	0 0 6	
Grey metal, with freestone	2 1 0	
Blue metal, mixed with catscope	0 3 0	
White comb	0 3 0	
Catscope	0 0 6	
Grey beds	1 4 0	
Black metal and stone	0 4 0	
Comb and catscope ...	0 3 1	
Comb...	0 2 4	
Catscope	0 0 3	
Comb...	2 5 4	
Rough metal ...	0 2 0	
COAL, good quality	0 1 4	
Black slate	0 0 4	
Cannel and Metal Band—	Ft. In.	
COAL, good quality ...	1 4	
Metal ...	0 1	
COAL, inferior ...	1 2	
Metal ...	0 1	
COAL, inferior ...	0 4	
Metal ...	0 1	
COAL, good quality ...	0 9	
Cannel ...	0 6	
Blue Tom ...	0 7	
COAL, good quality ...	0 11	
	0 5 10	
		19 0 5
Sill	0 2 0	
Girdle beds	0 5 0	
Freestone	0 2 0	
Comb...	1 5 0	
		3 2 0

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SECTION OF STRATA BELOW CANNEL BAND, GREYSOUTHEN.

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
COAL — *Cannel Band*		
Sill	0 4 7	
Grey beds	2 1 8	
Stone	0 0 4	
Comb metal ...	0 4 0	
COAL	0 0 4	
Grey beds	0 3 6	
Stone	0 0 7	
Comb metal ...	1 1 5	
Rattler and *coal* ...	0 0 11	
Sill	0 1 2	
Grey beds	1 3 11	
Soapy metal ...	1 2 3	
COAL—*Yard Band*	0 1 10	
		9 2 6
Sill	0 2 3	
Grey beds	0 4 2	
Parting	0 0 2	
Grey beds	0 2 10	
Comb metal ...	1 2 4	
Catscope bed ...	0 0 3	
Comb metal ...	0 1 6	
Parting	0 0 1	
Grey beds	0 4 0	
Comb metal ...	0 1 8	
Grey beds	1 2 9	
Comb metal ...	0 0 5	
Grey beds	0 5 7	
Comb metal ...	0 5 8	
Parting	0 0 2	
Comb metal ...	0 5 4	
Soapy metal ...	0 3 0	
Dark metal	0 4 0	
Parting	0 0 2	
Light metal ...	0 1 10	
Black parting ...	0 0 3	
Fine metal	0 0 6	
COAL	0 0 10	
Grey beds	0 4 0	
Stone	0 2 3	
Parting		
Stone	0 0 11	
Parting	0 0 1	
Stone	0 1 10	
Parting		
Stone	0 0 11	
Parting	0 0 2	
White stone ...	0 3 8	
Parting		
White freestone ...	0 4 0	
Grey beds	1 5 10	
Parting	0 0 1	
Carried forward	15 1 6	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	15 1 6	
Hard stone	0 0 5½	
Parting	0 0 1½	
Comb metal ...	0 3 0	
Dark metal	0 4 6	
Catscope	0 4 8	
Dark comb	0 0 7	
Rattler	0 0 4	
COAL—*Little Main Band*	0 2 0	
		17 5 2
Sill	0 1 8	
Comb metal ...	1 2 4	
Black metal and *coal*	0 0 9	
Comb metal ...	0 2 2	
Grey beds	0 2 3	
Hard stone	0 0 7	
Comb metal ...	0 4 7	
Black parting ...	0 0 3	
Comb metal ...	1 2 3	
Girdle beds	0 3 4	
Fine comb metal ...	0 0 9	
COAL	0 1 8	
		5 4 7
Black metal ...	0 0 1	
Brown sill	0 1 3	
Stone	0 2 8	
Parting		
Stone	0 1 0	
Girdle beds	0 3 11	
White stone ...	0 3 1	
Parting		
White stone ...	1 0 9	
Parting		
White stone ...	0 3 2½	
Strong comb ...	0 2 8	
Hard stone	0 2 0	
White post	0 5 8	
Parting		
Hard stone, brown cast	0 4 8	
Parting		
Brown stone ...	0 2 8	
Parting		
Stone	0 2 5	
Parting	0 0 1	
Hard stone, very white	0 2 11	
Parting		
Dark comb	0 1 4	
COAL — *Lickbank Seam*	0 5 0	
		8 3 4½

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SECTION OF HENRY PIT, BROUGHTON MOOR, BETWEEN TEN-QUARTERS AND CANNEL BAND.

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
COAL—*Ten-quarters*		1 0 8
Sill	0 4 0	
Caum...	1 2 0	
Blue metal	1 4 2	
COAL—*Rattler Seam*	0 2 4	
		4 0 6
Sill	0 2 6	
COAL and metal ...	0 2 0	
		0 4 6
Grey beds	3 0 3	
Fine metal	2 5 7	
Carried forward	5 5 10	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	5 5 10	
Stone...	4 0 6	
Main Stone	2 2 9	
Black metal	4 2 0	
COAL—*Crow Band*	0 2 9	
		17 1 10
Black metal	0 5 2	
COAL—*Metal Band*	0 4 0	
		1 3 2
Blue metal	0 2 6	
COAL—*Cannel Band*	0 5 6	
		1 2 0

SECTION OF BERTHA PIT, BROUGHTON MOOR, BELOW THE CANNEL BAND.

	Fs. Ft. In.	Fs. Ft. In.
COAL — *Cannel Band*		
Grey sill	1 2 0	
Grey metal	1 0 0	
White post	1 3 4	
Grey metal	0 2 10	
Grey post	0 3 2	
Grey metal	0 4 0	
Rattler	0 1 0	
		5 4 4
Grey post	0 2 6	
Grey metal... ...	0 2 0	
Post	0 2 10	
Blue metal	3 1 11	
COAL—*Yard Seam*	0 2 6	
		4 5 9
Sill	0 2 3	
Grey beds	1 1 2	
Blue metal	1 2 4	
Ironstone band ...	0 0 3	
Blue metal	0 1 7	
Grey beds	3 2 5	
Blue metal	0 0 9	
COAL	0 1 0	
		6 5 9
Sill	0 2 6	
Grey beds	0 1 6	
Ironstone nodules ...	0 0 6	
Grey beds	0 1 6	
Black metal ...	1 0 0	
Grey beds	0 4 6	
Light blue metal ...	3 0 0	
Brown stone ...	0 1 0	
Grey beds	0 2 10	
Blue metal	3 1 9½	
COAL—*Little Main*	0 2 1½	
		10 0 3
Sill	0 2 6	
Blue metal and ironstone girdles ...	2 0 6	
Light metal ...	0 0 6	
Carried forward	2 3 6	

	Fs. Ft. In.	Fs. Ft. In.
Brought forward	2 3 6	
Black metal ...	0 0 9½	
Ft. In.		
Rattler ... 0 2½		
COAL ... 1 4		
Metal ... 1 0		
COAL ... 0 4		
	0 2 10½	
		3 1 2
Cuttey sill	0 5 0	
Blue metal	2 2 0	
COAL	0 1 3½	
		3 2 3½
Brown sill	0 2 6	
Freestone sill ...	0 3 0	
Black stone *coal* ...	0 0 6	
Black stone sill ...	0 4 8	
Grey beds	1 4 2½	
Strong blue metal ...	0 2 6	
Strong light freestone and grey beds	0 5 0	
Blue metal	0 3 0	
White freestone beds	0 2 0	
Blue metal	0 3 0	
Ft. In.		
Rattler ... 1 0		
COAL ... 1 0		
	0 2 0	
		6 2 4½
Sill	0 2 6	
Dark metal... ...	0 3 0	
Blue metal	0 0 2	
COAL mark ...	0 0 1	
Sill	0 5 8	
Dark metal... ...	0 2 0	
Fine light blue metal, with catscope ...	1 5 0	
Black metal ...	0 1 3	
Grey metal	0 1 3	
COAL — *Lickbank Seam*	0 3 6	
		5 0 5

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SECTION OF ELLENBOROUGH PIT, MARYPORT.

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Soil and gravel ...	1 0 0	
Rough gravel ...	0 0 6	
Quicksand	3 0 0	
Strong blue clay ...	2 0 0	
Dark brown metal ...	5 0 0	
Light thill	0 3 0	
Dark blue metal ...	0 5 5	
Strong comb ...	0 4 2	
COAL	0 0 2½	
Dark blue comb ...	3 1 1	
COAL	0 1 4½	
		16 3 9
Dark blue metal ...	0 2 10½	
COAL	0 0 4½	
Dark blue metal ...	0 1 9	
Light blue comb ...	1 0 1	
White freestone ...	0 2 2	
Strong grey beds ...	1 1 9	
Dark cash	0 1 10	
Light blue metal ...	0 4 2	
Strong girdle, blue ...	0 0 9	
Dark blue metal ...	0 0 11	
COAL	0 0 6	
Dark blue comb ...	1 4 1	
Strong comb, with freestone	2 5 5	
Dark blue metal ...	1 5 4	
Black metal and *coal*	0 2 10½	
Light blue metal ...	1 0 0	
Grey beds	2 4 2	
Soft freestone ...	0 2 11½	
COAL — *Senhouse High Band* ...	0 3 8	
		16 3 8
Light coloured sill ...	1 1 0	
Light freestone bed	0 3 3	
Light coloured girdle beds	1 3 0	
Light freestone bed	0 0 10	
Dark comb metal beds, mixed with girdle beds 3 inches thick	1 3 0	
Black slate	0 0 3	
COAL	0 0 7	
Black stone	0 0 2	
COAL	0 0 7	
Black stone	0 0 1	
COAL	0 0 8	
		5 1 5
Sill, dark and slaty	0 1 0	
Brown coloured sill ...	1 1 0	
Ironstone bed ...	0 0 10	
Brown freestone ...	10 0 0	
Black metal	0 2 4	
Dark comb, mixed with a little catscope	1 1 8	
Carried forward	13 0 10	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	13 0 10	
Dark comb	6 0 0	
COAL	0 2 4	
		19 3 2
Black scram ...	0 0 3	
Light coloured sill ...	0 1 2	
Black mark ...	0 0 1½	
Light coloured sill ...	0 3 9	
Light freestone ...	0 3 0	
Light comb	0 4 0	
Light freestone post	0 1 1	
Light metal ...	0 1 1	
COAL	0 0 6	
Blue metal sill ...	0 4 0	
Light comb and grey beds, mixed with catscope	3 0 0	
Black metal, mixed with a little *coal* ...	0 0 6	
Light comb and grey beds, mixed with catscope beds some 6 inches thick ...	1 4 0	
Light grey beds, with vegetable impressions at the bottom	0 1 0	
Light hard stone ...	0 1 3	
Light coloured grey beds	1 0 0	
Light stone bed ...	5 0 6	
COAL — *Hamilton Seam*	1 1 0	
		15 3 2½
Grey beds	1 3 0	
Girdle beds	1 2 0	
Grey beds	0 1 10	
COAL	0 0 8	
Dark comb metal ...	10 4 4	
Dark blue metal ...	1 0 8	
COAL (average quality) — *Virgin Seam*	0 2 6	
		15 3 0
COAL, stone ...	1 1 8	
Comb, with stone beds	4 2 9	
Dark grey metal ...	1 1 9	
COAL — *White Metal Band*	0 4 8	
		7 4 10
Blue comb metals ...	0 4 3	
Grey beds	0 1 0	
Comb metal	0 4 6	
Hard girdle	0 5 4	
Fine blue metal ...	0 3 10	
Strong comb ...	0 2 1	
Blue stone	0 2 4	
Light coloured stone	0 5 10	
Light blue comb, with catheads	1 1 0	
Parting	0 0 3	
Carried forward	6 0 5	

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SECTION OF ELLENBOROUGH PIT, MARYPORT.—*Continued.*

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	6 0 5	
COAL—*Ten-quarters*— Ft. In.		
COAL ... 2 0		
Metal mixed with *coal* 0 8		
COAL ... 0 10		
Parting ... 0 3½		
COAL ... 1 10		
Parting ... 0 1½		
COAL ... 0 8		
Spar, bad ... 0 5		
Spar, good 0 4		
COAL ... 1 3		
	1 2 5	
		7 2 10
Grey sill	0 4 6	
Black comb, with hard catscopes	1 4 1	
Fine light freestone	1 0 3	
Catscope	0 0 5	
Coloured comb, with catscope beds ...	1 3 10	
COAL — *Rattler Band*	0 5 2	
		6 0 3
Dark soft sill ...	0 1 6	
Dark freestone sill ...	0 3 6	
Comb, with catscope beds	2 1 9	
Carried forward	3 0 9	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In
Brought forward	3 0 9	
Grey metal	0 2 7	
Grey beds	0 2 4	
Black metal	0 2 0	
Girdle beds	1 1 5	
Stone, black coloured	5 5 7	
Metal parting ...	0 0 5	
Stone, black coloured	4 2 2	
Cash, or black metal	0 0 2	
Crow Band—		
COAL	0 1 0	
Metal and spar ...	0 0 6	
COAL	0 0 10½	
		16 1 9½
Black metal ...	0 1 7	
Metal Band—		
COAL	0 1 6	
Slate	0 0 9	
COAL and rattler	0 0 4½	
COAL	0 0 10½	
		0 5 1
Grey metal sill ...	0 2 6	
Blue comb	0 4 2	
Grey beds	0 3 8	
Blue comb	1 0 9	
Dark grey metal ...	0 1 11	
Black cash	0 0 11	
COAL — *Cannel Band*	0 5 7	
		4 1 6

SECTION OF BORE IN STRATA BELOW CANNEL BAND, ELLENBOROUGH PIT.

	Fs. Ft. In.	Fs. Ft. In.
Light grey metal ...	0 4 6	
Dark metal, with stone	0 4 6	
Comb metal	0 3 2	
Black stone	0 2 3	
Strong grey stone ...	0 1 6	
Blue comb metal and stone	1 1 9	
Light freestone ...	0 3 5	
Strong grey stone ...	0 0 10	
Light freestone ...	0 2 2	
Comb metal and stone	0 4 7	
Light blue comb metal	0 2 9	
COAL and splint ...	0 1 0	
		6 2 5
Light metal	0 1 4	
Strong comb metal ...	1 0 2	
Strong grey stone ...	0 5 2	
Light freestone ...	0 1 2	
Strong grey stone ...	0 1 0	
Comb metal and stone	0 1 0	
Blue comb metal ...	2 2 0	
COAL and splint ...	0 2 3	
		5 2 1
Light grey metal ...	0 2 6	
Freestone	0 3 11	
Carried forward	1 0 5	

	Fs. Ft. In.	Fs. Ft. In.
Brought forward	1 0 5	
Strong grey beds ...	0 3 3	
Comb metal	0 4 0	
Light blue metal ...	0 2 5	
COAL	0 0 3	
White freestone thill	0 3 4	
Light grey freestone	0 2 0	
Grey comb metal ...	0 1 3	
Light grey freestone	0 2 0	
Light grey comb ...	0 2 0	
Comb metal	0 3 0	
Grey metal with catscope	0 0 6	
Light blue metal ...	0 1 8	
Light grey comb ...	0 1 6	
Catscope	0 0 4	
Black splint or shale ...	0 0 6	
Blue metal comb ...	0 0 6	
Catscope	0 0 3	
Blue metal comb ...	0 4 6	
Catscope	0 0 4	
Dark grey comb ...	0 5 0	
Catscope	0 0 3	
Dark metal	0 1 2	
Strong grey beds ...	0 4 2	
Dark splint or shale ...	0 0 3	
Carried forward	8 2 10	

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SECTION OF BORE IN STRATA BELOW CANNEL BAND, ELLENBOROUGH PIT.—*Continued.*

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	8 2 10	
Stone comb	0 3 6	
Blue comb	0 1 10	
Catscope	0 0 3	
Blue comb metal ...	0 2 0	
Strong blue comb ...	0 3 1	
Grey stone	0 0 4	
Light blue metal ...	0 0 10	
Dark cash metal ...	0 3 6	
Light blue metal ...	0 1 8	
Dark metal	0 0 6	
COAL	0 0 11	
Comb metal	0 0 4	
Light grey thill ...	0 1 4	
Grey beds	1 3 6	
Light grey freestone	0 1 0	
Light grey comb ...	0 0 6	
Carried forward	13 3 11	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	13 3 11	
White stone	0 0 6	
Light grey freestone	0 1 0	
Blue comb metal ...	0 1 8	
Light grey freestone	0 0 4	
White freestone ...	0 1 4	
Grey freestone ...	0 0 3	
COAL	0 0 8	
Black splint	0 0 1	
Strong grey thill ...	0 5 6	
Dark comb	0 2 0	
Strong grey beds ...	0 2 8	
Grey comb	0 1 6	
Strong grey comb beds	0 1 0	
Grey stone	0 1 0	
Light comb, with stone	0 4 5	
Blue comb	0 4 0	
		18 1 10

SECTION OF JOHN PIT, DEARHAM, BELOW TEN-QUARTERS SEAM.

	Fs. Ft. In.	Fs. Ft. In.
COAL—*Ten-quarters*		1 0 0
Sill and dark metal ...	0 3 0	
Blue metal stone ...	1 0 0	
Blue freestone ...	1 0 0	
Blue whinstone ...	0 2 4	
Dark blue metal ...	2 2 0	
COAL—*Rattler Seam*	0 2 4	
		5 3 8
Brown metal sill ...	0 0 6	
COAL	0 0 6	
COAL, slaty ...	0 1 6	
		0 2 6
Blue metal	0 3 0	
Black metal	0 4 0	
COAL—*Brick Seam*	0 2 0	
		1 3 0
Light stone sill ...	0 3 0	
COAL	0 0 9	
Light blue metal ...	3 0 0	
Post girdle	0 1 1	
Dark blue metal ...	0 3 0	
Dark grey metal ...	0 3 0	
Light blue metal ...	0 4 0	
Dark blue metal ...	0 0 2	
Dark and blue metal	1 3 0	
Blue metal	1 2 0	
COAL—*Crow Seam*	0 2 6	
		8 4 6
Dark metal and iron-stone	1 0 0	
COAL—*Metal Band*	0 1 6	
Black metal	0 0 6	
COAL and rattler ...	0 1 8	
		1 3 8
Brown soft sill ...	0 1 2	
COAL, including metal—*Cannel Seam*	0 5 4	
		1 0 6

	Fs. Ft. In.	Fs. Ft. In.
Sill	0 1 6	
Dark blue metal ...	2 0 4	
Dark blue metal, with iron posts	1 5 8	
Post girdle	0 0 6	
Dark blue metal ...	2 3 0	
COAL	0 0 7	
Black metal	0 0 7	
Light metal	0 2 0	
Fine blue metal ...	3 0 0	
Black metal	0 0 7	
COAL	0 2 2	
		10 4 11
Blue metal sill ...	0 0 9	
Blue metal stone ...	0 5 6	
COAL	0 0 6	
Brown sill	0 0 5	
Grey metal stone ...	0 3 0	
Light blue metal ...	2 0 2	
Blue post girdle ...	0 0 8	
Dark parting ...	0 0 1	
Light blue metal ...	4 4 7	
Black metal	0 4 10	
Black metal stone ...	0 2 5	
COAL	0 1 3	
		10 0 2
Brown metal ...	0 1 6	
Dark grey metal ...	0 1 2	
Dark grey freestone...	1 5 6	
Light grey freestone	0 2 7	
Dark parting and light freestone	0 2 7	
Grey beds freestone...	0 2 4	
Light grey freestone	3 3 10	
Brown freestone ...	0 2 9	
Blue metal stone ...	2 1 2	
COAL seam ...	0 2 3	
		10 1 8

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SECTION OF JOHN PIT, DEARHAM, BELOW TEN-QUARTERS SEAM.—*Continued.*

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brown metal sill ...	0 3 0	
Blue metal	3 2 9	
Black metal	0 1 8	
COAL	0 1 0	
		4 2 5
Brown sill and *coal*...	0 1 2	
Dark brown stone ...	0 3 0	
Grey freestone ...	0 2 7	
Carried forward	1 0 9	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	1 0 9	
Blue grey freestone...	0 2 1	
Blue grey metal ...	2 5 9	
Blue metal stone ...	1 3 8	
COAL	0 3 2	
		6 3 5
Dark brown metal ...	0 0 6	
COAL and metal ...	0 1 4	
Dark brown sill ...	0 4 4	
		1 0 2

SECTION OF ROSEGILL PIT, BULLGILL, TO TEN-QUARTERS SEAM.

	Fs. Ft. In.	Fs. Ft. In.
Red dappled thill ...	1 0 0	
Dark grey quarry stone	15 1 6	
Red metal	2 2 0	
Red dappled thill ...	0 5 6	
Stone comb metal ...	1 4 0	
Light grey stone ...	1 0 0	
Red dappled thill ...	0 5 0	
Stone comb metal ...	1 3 4	
Grey stone, mixed with metal ...	0 2 6	
Red sill	0 0 8	
Stone comb metal ...	1 0 0	
Fine blue metal ...	0 2 3	
Light metal... ...	0 3 0	
Dark red stone metal	1 3 0	
Hard grey stone ...	0 1 6	
Dark red metal ...	1 1 0	
Light metal... ...	0 1 0	
Red metal, with iron beds	1 5 0	
Strong grey stone ...	4 0 0	
Metal parting ...	0 0 0½	
Strong grey stone ...	0 4 6	
Red metal	0 1 6	
Light grey stone ...	0 3 0	
Red metal, with iron-stone beds ...	1 2 6	
Ironstone bed ...	0 0 4	
Dark blue metal, with ironstone beds ...	1 1 6	
Dark metal	0 0 2	
Dark blue stone ...	0 1 0	
Black metal... ...	0 0 2	
COAL	0 0 2	
Light thill	0 4 3	
Hard blue stone ...	1 1 6	
Hard white freestone	1 3 0	
Hard stone, dappled red	0 4 6	
Dark coloured thill...	0 1 6	
Hard stone, dappled red	0 2 0	
Stone comb metal ...	0 4 0	
Fine blue metal, with ironstone beds ...	1 2 6	
Carried forward	47 1 4½	

	Fs. Ft. In.	Fs. Ft. In.
Brought forward	47 1 4½	
Black shivery metal	0 1 0	
Fine white thill ...	0 2 0	
White freestone ...	0 4 0	
Dark blue comb metal	0 5 0	
COAL	0 0 3	
Light thill	0 4 0	
Light comb metal, with ironstone bed	2 3 6	
Dark blue metal ...	3 3 6	
COAL	0 0 3	
Dark metal... ...	0 0 3	
COAL	0 0 1	
Dark metal... ...	1 0 6	
COAL	0 1 9	
		57 3 5½
Dark thill, with ribs of freestone ...	0 5 10	
Grey beds	2 5 6	
Fine comb metal ...	0 4 10	
Dark shivery metal...	0 0 8	
COAL	0 1 2½	
		5 0 0½
Dark metal... ...	0 1 2	
COAL	0 0 2½	
Dark thill, mixed with freestone... ...	1 0 0	
Black band... ...	0 0 10	
Light metal ...	0 0 3	
Black metal... ...	0 0 5½	
COAL	0 0 3½	
Dark thill	0 0 10	
Light grey thill ...	0 3 0	
White freestone ...	1 0 0	
Fine metal	0 5 6	
Curled thill... ...	0 5 0	
COAL	0 0 11	
Metal	0 0 7	
COAL	0 0 1	
Grey curled thill ...	0 4 0	
Strong comb metal, with ribs of free-stone	8 3 0	
Dark metal, with iron-stone beds ...	2 3 0	
COAL — *Ten-quarters Seam* ...	1 0 8	
		17 5 9½

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SECTION OF ELLEN PIT, BULLGILL, BELOW TEN-QUARTERS SEAM.

	Thickness of each Stratum. Fs.	Ft.	In.	Depth Coal Seams are apart. Fs.	Ft.	In.
COAL — *Ten-quarters Seam*				1	1	0
Dark metal sill ...	1	3	0			
Strong light blue metal	3	5	6			
COAL—*Rattler Band*	0	2	10			
				5	5	4
Strong light metal sill	0	3	8			
COAL—*Slaty Band*, mixed *coal* and metal	1	1	0			
				1	4	8
Strong brown freestone	1	3	3			
COAL	0	1	0			
				1	4	3
Light metal sill ...	0	2	3			
Flinty freestone post...	0	5	6			
Blue metal	6	1	0			
Black metal	0	3	6			
COAL—*Thirty-inch Seam*	0	3	0			
				8	3	3
Black metal, with many ironstone beds ...	1	2	6			
COAL—*Metal Band*	0	5	6			
				2	2	0
Light freestone beds...	1	0	6			
Light strong metal ...	0	4	0			
COAL—*Cannel Seam*	1	5	0			
				3	3	6
Metal sill	0	3	0			
Strong blue metal ...	1	2	0			
Black stone and rattler	0	2	0			
Black metal	0	2	0			
Light blue metal and thin beds of freestone	3	2	0			
COAL, with rattler on top	0	1	0			
				6	0	0
Strong light blue metal	3	3	0			
COAL—*Yard Seam*	0	3	0			
				4	0	0
White freestone sill ...	0	3	0			
Grey beds	0	3	0			
Stone metal	0	4	9			
COAL	0	0	9			
Sill	0	1	6			
White post	1	2	4			
Grey beds	0	3	7			
Carried forward	4	0	11			

	Thickness of each Stratum. Fs.	Ft.	In.	Depth Coal Seams are apart. Fs.	Ft.	In.
Brought forward	4	0	11			
Blue metal	0	4	8			
Ironstone bed, with parting	0	0	2			
Black metal ...	0	1	0			
Dark sill	0	4	8			
Dark sparkly sill ...	0	2	9			
Light grey beds ...	0	2	0			
Ironstone bed, with parting	0	0	2			
Strong blue metal ...	1	0	5			
Ironstone bed, with parting	0	0	2			
Stone metal	0	2	6			
Strong grey beds ...	1	1	6			
Whirlstone	0	2	6			
Stone metal	1	4	0			
Dark strong metal ...	1	0	0			
Light blue metal ...	0	3	6			
Black metal	0	1	6			
COAL	0	0	9			
Sill	0	2	6			
COAL	0	1	1			
				14	0	9
Sill	0	5	6			
Stone metal	1	5	10			
Soft parting	0	0	2			
Strong dark metal ...	0	3	0			
Blue metal	1	0	8			
COAL—*Little Main*	0	2	2			
				4	5	4
Strong sill	0	4	0			
Blue flinty post ...	0	2	6			
Blue metal, with ironstone beds... ...	0	5	6			
Strong light blue metal	2	3	5			
Black stone	0	0	6			
COAL	0	1	6			
				4	5	5
Sill	0	5	0			
White freestone ...	0	5	0			
Strong blue metal ...	2	4	0			
COAL — *Lickbank Seam*	0	1	6			
				4	3	6
Black metal	0	0	6			
White freestone ...	0	4	6			
				0	5	2

SECTION OF ASPATRIA No. 3 PIT.

	Fs.	Ft.	In.	Fs.	Ft.	In.
Soil and sand... ...	0	5	0			
Sand and gravel ...	1	3	0			
Brown clay	2	4	0			
Red sill	0	2	8			
Dark metal	0	0	8			
Blue metal	0	5	6			
Brown metal... ...	0	3	0			
Carried forward	6	5	10			

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward	6	5	10			
Dark blue metal ...	0	3	6			
Dark brown metal ...	0	4	8			
Brown freestone comb	0	3	0			
Brown post	0	1	0			
Brown comb... ...	2	5	0			
Brown sandstone ...	3	5	0			
Comb metal	1	4	0			
Carried forward	17	2	0			

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SECTION OF ASPATRIA No. 3 PIT.—*Continued.*

	Thickness of each Stratum. Fs.	Ft.	In.	Depth Coal Seams are apart. Fs.	Ft.	In.
Brought forward	17	2	0			
Grey freestone ...	0	2	0			
Randed comb ...	0	2	6			
Black parting ...	0	0	1			
Dark sill	0	4	6			
Brown post	0	1	3			
Dark blue metal ...	0	0	9			
Dark slate and *coal*...	0	0	3			
Grey sill	0	2	0			
Brown sill	0	1	0			
Light comb	1	2	0			
Dark brown comb ...	0	2	0			
Light comb	0	2	0			
Dark comb metal ...	0	2	6			
Brown comb metal ...	1	3	0			
Blue metal and cats-cope	2	1	0			
Randed comb ...	0	1	0			
Blue metal	0	2	0			
Black metal and stone	0	4	6			
COAL	0	0	4			
Strong dark sill ...	0	1	0			
Strong dark comb ...	0	3	0			
COAL	0	1	2			
				27	5	10
Sill	0	5	0			
Strong comb... ...	3	0	0			
Stone and grey beds...	0	4	0			
Strong comb... ...	1	0	0			
Blue metal	2	3	0			
Sticking	0	0	6			
Blue metal	1	0	0			
Dark metal	0	0	6			
COAL	0	1	6			
				9	2	6
Dark metal	0	0	5			
COAL	0	0	11			
Dark metal	0	1	2			
COAL	0	0	5			
Slate and *coal* mixed	0	3	3			
Sill	0	3	6			
Stone comb	5	0	0			
White freestone ...	1	0	0			
Stone comb	0	1	0			
White freestone ...	0	2	0			
Black metal	0	0	3			
Brown post or sandstone	0	3	1			
Grey beds (lodge) ...	1	2	2			
Randed grey beds ...	4	0	0			
Brown post	0	3	0			
White freestone ...	0	1	9			
Randed grey beds ...	0	4	7			
White freestone ...	0	3	0			
Blue metal	0	1	7			
Black metal	0	1	6			
COAL	0	0	4			
Soft sill	0	0	6			
Strong sill	0	4	0			
Blue metal	2	0	0			
Carried forward	19	2	5			

	Thickness of each Stratum. Fs.	Ft.	In.	Depth Coal Seams are apart. Fs.	Ft.	In
Brought forward	19	2	5			
Blue metal and cats-cope	1	0	0			
Black metal	0	0	6			
COAL	0	1	8			
				20	4	
Strong thill	0	1	6			
Sill, mixed with *coal*...	1	2	0			
Stone comb	3	0	6			
Blue metals	1	0	3			
COAL	0	0	11			
Soft sill	0	0	4			
Strong sill	0	3	8			
Strong comb... ...	0	4	0			
Blue metal	0	1	6			
COAL, slaty ...	0	1	5			
				7	4	1
Dark sill	0	4	0			
Grey freestone ...	1	0	0			
Blue metal	0	3	0			
Randed black metal...	0	4	3			
COAL	0	0	1			
Strong sill	1	3	0			
Randed freestone ...	0	2	3			
White freestone ...	1	4	0			
Black metal and *coal*	0	1	2			
Strong sill	0	1	8			
Dark blue metal ...	1	0	0			
Light grey comb ...	1	0	0			
Dark grey comb ...	1	3	0			
Strong grey beds ...	0	3	0			
Dark comb metal ...	0	1	10			
Blue metal	0	0	4			
Dark comb metal ...	0	4	0			
Grey beds	0	3	6			
Blue metal	0	0	4			
White freestone ...	0	2	3			
Dark grey beds ...	0	1	6			
Strong grey beds ...	2	2	0			
Dark blue metal ...	0	1	3			
Grey beds	0	2	6			
Comb and grey beds...	0	5	0			
Grey beds	0	3	0			
Comb and grey beds...	2	5	6			
Grey beds	0	2	6			
Strong comb... ...	0	1	6			
Blue metal	0	0	6			
White freestone ...	0	4	4			
Blue metal	0	0	3			
White freestone ...	0	1	0			
Blue metal	0	0	8			
White freestone ...	0	1	0			
Grey comb	0	2	0			
Blue metal	0	2	6			
COAL—*Yard Band*	0	4	9			
				23	5	0
Dark sill	0	3	6			
Dark blue metal ...	1	1	0			
Black metal and *coal*	0	1	6			
				2	0	0

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SECTION OF BORE BELOW YARD BAND, FOOT OF AIR PIT, NO. 1 PIT, ASPATRIA.

	Thickness of each Stratum. Fs.	Ft.	In.	Depth Coal Seams are apart. Fs.	Ft.	In.
COAL—*Yard Band*	—			34	0	0
Grey sill	0	1	9			
Strong comb	1	0	3			
Light freestone ...	0	3	5			
Stone comb	0	5	0			
Comb metal	0	2	9			
Brown catscope ...	0	0	5			
Blue metal	0	1	6			
Dark metal	0	0	8			
Sill and comb metal ...	0	4	6			
Stone and grey beds ...	0	3	0			
Grey comb	0	1	10			
Comb metal	0	2	9			
Grey stone	0	1	0			
Comb metal	0	4	4			
Strong comb	1	3	6			
Comb metal	0	1	6			
Light brown catscope	0	0	6			
Comb metal	0	1	8			
Dark comb	0	2	0			
Black metal	0	1	0			
Grey stone	0	0	10			
Dark comb metal ...	0	2	6			
Blue metal	0	2	0			
Black slaty metal ...	0	0	10			
COAL	0	1	5			
				10	2	11
Grey sill	0	1	0			
Light comb	0	3	0			
Stone comb	1	5	0			
Grey freestone ...	0	1	6			
Grey comb	0	1	0			
Grey freestone ...	0	0	8			
Stone comb	0	3	0			
Grey comb	0	5	0			
Dark comb metal ...	0	2	10			
Grey comb	1	0	0			
Blue metal	2	1	6			
COAL—*Little Main Band*	0	2	2			
				8	2	8
Light sill	0	2	0			
Light comb	0	3	0			
Grey comb	0	3	0			
Light blue metal ...	1	1	0			
Black metal and splint	0	3	0			
Slate and *coal* ...	0	0	10			
COAL	0	0	8			
Dark sill	0	3	10			
Grey comb	1	3	0			
Fine blue metal ...	0	0	9			
Soft black metal and rattler	0	1	2			
COAL and slate ...	0	0	3			
Soft light stone sill ...	0	2	0			
Stone comb	0	5	6			
Dark metal parting ...	0	0	2			
Dark comb	0	0	7			
Carried forward	7	0	9			

	Thickness of each Stratum. Fs.	Ft.	In.	Depth Coal Seams are apart. Fs.	Ft.	In.
Brought forward	7	0	9			
Soft grey freestone ...	0	0	10			
Black metal	0	1	0			
COAL and slate ...	0	0	9			
Strong grey sill ...	0	0	8			
Light freestone ...	0	2	2			
Grey beds	0	1	6			
Dark comb and catscope	0	4	2			
Black slaty metal ...	0	0	7			
COAL and slate ...	0	0	5			
Grey sill	0	1	4			
Light stone comb ...	0	2	6			
Light grey beds ...	0	1	0			
White freestone ...	0	1	6			
Light stone comb ...	0	1	8			
Strong stone, in two posts	0	2	5			
Strong grey comb ...	2	0	0			
Comb metal	1	0	7			
Dark blue metal ...	0	1	1			
COAL	0	1	0			
				14	1	11
Soft cashy metal ...	0	1	3			
Lickbank Seam—						
COAL	0	0	5			
Metal	0	0	1			
COAL	0	0	6			
Dark sill	0	0	9			
Light sill	0	1	0			
Strong light comb ...	0	4	11			
Light freestone ...	0	1	6			
Stone comb and grey beds	1	4	2			
White freestone post	0	2	10			
Strong grey comb ...	0	3	3			
White freestone post	0	1	0			
Stone comb	0	1	4			
White freestone post	0	2	5			
Stone comb and grey beds	0	3	0			
Strong grey beds ...	1	3	0			
Grey comb	0	1	2			
Light freestone ...	0	2	6			
COAL	0	0	11			
Soft dark metal ...	0	0	2			
COAL and slate ...	0	0	4			
Dark sill	0	0	4			
Light yellow freestone	0	1	4			
Grey beds	0	2	8			
Dark randed comb ...	0	1	2			
Light freestone ...	0	1	11			
Dark randed comb ...	0	1	6			
Dark comb	0	3	9			
Grey freestone ...	0	0	8			
Dark comb	0	0	8			
Grey freestone ...	0	0	8			
Carried forward	10	3	2			

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SECTION OF BORE BELOW YARD BAND, FOOT OF AIR PIT, No. 1 PIT, ASPATRIA.—*Continued.*

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	10 3 2	
Dark comb	0 4 6	
Strong grey beds ...	0 5 6	
Dark comb metal ...	0 5 6	
Black slaty metal ...	0 0 10	
Rattler and splint ...	0 0 6	
Soft metal	0 0 2	
Strong comb... ...	0 0 4	
Soft cashy metal ...	0 0 4	
Black metal and *coal*	0 1 1	
Dark grey sill ...	0 1 4	
Light stone comb ...	0 2 6	
White freestone ...	0 1 0	
Stone comb	0 2 0	
White freestone ...	0 3 3	
Grey stone comb ...	0 2 9	
Grey freestone ...	0 1 4	
Grey comb	0 1 0	
Light comb metal ...	1 3 9	
COAL	0 1 3	
		18 0 1
Black stone	0 0 2	
Dark grey sill ...	0 2 4	
Dark stone comb ...	1 1 3	
Strong grey comb ...	0 4 2	
Light cream coloured stone	1 5 6	
Dark grey comb ...	0 1 10	
Strong grey beds ...	0 0 11	
Dark grey comb, randed with stone	0 3 9	
Grey catscope ...	0 0 4	
Grey comb metal ...	0 3 0	
Dark metal	0 2 0	
Fine blue metal ...	0 3 0	
Dark blue metal ...	0 3 6	
Dark strong metal ...	0 1 10	
COAL	0 0 11	
Dark cashy metal ...	0 0 8	
Light metal	0 0 10	
Dark black metal ...	0 3 9	
COAL	0 1 10	
		8 5 7
Splint	0 0 6	
Light sill	0 0 8	
Strong brown and grey stone	0 2 7	
Light yellow stone ...	0 1 8	
Laying-in post, very hard	0 1 11	
Stone and grey beds...	0 1 7	
Strong grey stone ...	0 0 8	
Light stone and stone comb	0 2 1	
Carried forward	1 5 8	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	1 5 8	
Dark grey stone comb	0 2 4	
Strong grey comb ...	1 1 0	
Dark grey stone comb	0 3 6	
Soft sticking... ...	0 0 2	
Strong grey bed and stone	1 0 0	
Strong grey comb ...	0 2 0	
Strong dark comb ...	0 4 0	
Dark comb	0 3 6	
Grey stone post ...	0 0 3	
COAL, slaty ...	0 0 4	
Strong dark sill ...	0 0 4	
Light yellow freestone	0 2 8	
Light stone comb ...	0 0 4	
Light yellow freestone	0 2 0	
Strong light comb ...	0 5 3	
Grey comb	0 1 8	
Strong grey beds . .	0 3 0	
Light comb	0 1 0	
Dark grey comb ...	0 3 8	
Dark cashy metal ...	0 1 6	
Strong grey comb ...	0 1 0	
Light freestone ...	0 1 0	
Strong light grey stone	4 1 10	
Dark scram or comb...	0 0 6	
Grey comb	0 1 0	
Light grey freestone...	1 3 0	
Strong grey beds ...	0 1 2	
Dark comb metal ...	0 0 8	
Strong grey comb ...	0 2 0	
Black scram and dark cashy metal ...	0 1 10	
Light grey freestone...	1 1 0	
Light grey beds ...	0 2 2	
Light stone	0 1 0	
Strong grey beds ...	0 1 0	
Light grey freestone	0 5 2	
Strong dark grey comb	0 1 10	
Light grey freestone...	0 1 9	
Dark grey comb ...	0 3 0	
Light grey beds ...	1 0 4	
Dark grey comb ...	1 0 2	
Strong grey stone ...	0 1 9	
Grey comb	0 1 6	
Light grey stone ...	0 0 7	
Dark grey comb ...	1 5 0	
Strong grey stone ...	0 2 0	
Light blue comb ...	0 0 9	
Light stone post, with lime	0 1 0	
Soft parting	0 0 1	
Light stone, strong ...	0 1 4	
		26 5 7

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SECTION OF No. 2 PIT, BOLTON COLLIERY.

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Soil	0 1 0	
Sand and brown clay	1 1 0	
Sand and gravel ...	1 5 0	
Strong brown clay ...	4 0 0	
Soft blue sill... ...	0 0 6	
Red comb	1 0 0	
Brown sandstone and red comb	1 1 0	
Brown and blue metal	1 4 0	
Strong grey stone ...	0 0 10	
Blue metal	1 0 0	
COAL, stone, and black stone and *coal* mixed	0 5 8	
		13 1 0
Light grey sill ...	0 2 6	
Blue metal	1 3 6	
Black splint or rattler	0 1 2	
Light blue metal ...	0 5 0	
Black slate	0 0 2	
COAL	0 1 5	
		3 1 9
Soft sill	0 1 2	
Light grey sill ...	0 5 6	
Strong brown sill ...	0 2 0	
Strong light comb, randed with stone	3 2 0	
Brown stone comb ...	2 0 0	
Strong brown stone...	3 0 0	
Thin posts of stone, with red partings...	0 4 0	
Black slate and cashy metal	0 0 6	
Dark grey sill ...	0 2 6	
Blue and brown comb	1 0 0	
Stone comb, randed with stone... ...	1 0 0	
Light comb	0 3 0	
Brown comb... ...	1 1 0	
Blue comb	1 0 0	
Strong grey bed and stone	1 0 0	
Strong grey comb ...	1 0 0	
Strong grey bed and stone	4 1 0	
Light grey comb ...	1 0 0	
Carried forward	22 4 8	

	Thickness of each Stratum. Fs. Ft. In.	Depth Coal Seams are apart. Fs. Ft. In.
Brought forward	22 4 8	
Dark grey comb ...	0 3 0	
Soft sticking... ...	0 0 2	
Light grey stone sill	0 1 8	
Strong grey metal ...	1 2 0	
COAL	0 0 8	
Strong dark grey sill	0 1 8	
Grey beds	1 0 0	
Light grey freestone	0 2 0	
Blue metal	0 1 0	
Dark comb	0 4 0	
Rattler	0 0 3	
White freestone ...	0 2 4	
Brown freestone ...	0 2 8	
Strong grey bed ...	0 2 0	
White freestone ...	0 3 6	
Dark comb	0 0 6	
Strong brown grey stone	0 5 6	
Black metal and rattler	0 2 0	
Dark grey stone ...	0 0 5	
Light blue metal ...	1 2 0	
Dark grey stone ...	0 0 7	
Black cashy metal ...	0 0 7	
Strong grey sill ...	1 1 0	
Dark sill	0 2 0	
Strong grey comb ...	0 3 0	
Stone and grey beds...	2 2 6	
Strong grey comb, randed with stone	0 4 0	
Dark blue metal ...	0 1 3	
Light blue comb ...	0 5 7	
Dark blue metal, full of catscope ...	0 5 0	
COAL — *Yard or Main Band* ...	0 5 6	
		40 1 0
Strong light sill ...	0 5 0	
Strong grey comb ...	1 2 0	
Blue metal	0 4 6	
Dark grey stone and catscope	0 1 6	
		3 1 0

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To enable a comparison of these sections to be made with greater certainty and ease they are given side by side in another form on Plate XXXIII. The names there given to the various seams are those by which they are actually known in the different districts where the sections are taken, and the correlation of the seams, according to the judgment of the writer, is shown by means of the fine lines connecting the different seams. This drawing has been prepared by uniting in one column for each locality the details given in the foregoing journals. For example, the Whitehaven section was obtained by taking the details of Croft Pit as far down as the Bannock Band and the details of Wellington Pit from the Bannock Band down to the Six-quarters Coal. Below the Six-quarters Coal the information was obtained by a borehole in Wellington Pit. The other sections, for Cleator Moor, Harrington, and Workington, etc., were prepared in a similar way, and all the details are given in the preceding journals.

By reference to Plate XXXIII. it will be seen that the Yard Band is the seam which most nearly preserves its name throughout the district.*

The Lickbank of Greysouthen is the Hamilton Band of Workington, the Three-feet Band of Harrington, the Six-quarters Coal of Whitehaven, and the Low Bottom Band of Cleator Moor. The Lickbank seam at Broughton Moor and Dearham appear to be two different seams. They are also different from the Lickbank of Greysouthen.

The Main Band of Whitehaven, Cleator Moor, and Workington are no doubt one and the same seam. In other parts of the district this seam is known as the Cannel and Metal Band.

The Bannock Band of Cleator Moor and Whitehaven corresponds to the Little Main of Workington and to the Rattler Band of other parts of the district.

The Five-feet Coal of Cleator Moor is the Moor Banks Band of Workington and the White Metal Band of Ellenborough.

As these correlations differ in one most important matter from that which is generally accepted in the district, it will be necessary to give the reasons which have induced the change. It is generally considered that the Moor Banks Band of Workington and the Ten-quarters Coal of Ellenborough, Bullgill, Dearham, Broughton Moor, and Greysouthen, are

* At Whitehaven there is a Yard Band above the Bannock Band, but the seam which corresponds to the Yard Band of the other parts of the district has not been worked there. At Workington the Yard Band seems to be the Little Main of other areas.

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one and the same seam. It is also considered that the Bannock Band of Whitehaven is the same seam as the Bannock Band of Cleator Moor. Both these correlations are doubtless correct, but it is further thought that the Ten-quarters Coal, in the first-mentioned districts, is the same seam as the Bannock Band of Whitehaven and Cleator Moor. This seems to be wrong, the Ten-quarters Coal being more probably the Five-feet Coal of Cleator Moor, whilst the Bannock Band of that district and of Whitehaven corresponds to the Rattler Band of Ellenborough and the other places above-mentioned. The reasons for this alteration, which affects the relative position of all the seams above the Main Band at both Whitehaven and Cleator Moor, are as follows:—

1.—On the new correlation there is a closer correspondence in the distance between the different seams than there is on the old view as shown below:—

ELLENBOROUGH.

	Fms.	Ft.	In.
From the Ten-quarters Coal to the Rattler Band is ...	6	0	3
„ „ Cannel and Metal Band	27	2	7

CLEATOR MOOR.

From the Five-feet Coal to the Bannock Band is	6	5	8
„ „ Main Band	26	1	8

It will be seen from this statement that there is only 19 fathoms 2 feet between the Bannock Band and Main Band at Cleator Moor, as compared with 27 fathoms 2 feet 7 inches between the Ten-quarters Coal and the Cannel and Metal Band at Ellenborough.

2.—The sections of the seams in the different districts are more nearly alike on the new view than on the old one.

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Sections of Seams.

At Ellenborough.

White Metal Band.

	Ft.	In.
COAL	1	0
Metal	2	0
COAL	1	8
	4	8

Ten-quarters Coal.

	Ft.	In.
COAL	2	0
Metal	0	8
COAL	0	10
Parting	0	3½
COAL	1	10
Parting	0	1½
COAL	2	8
	8	5

Rattler Band.

	Ft.	In.
Rattler	0	6
COAL	2	2
Parting	0	1
COAL	0	2
Dark grey metal	1	6
COAL	0	9
	5	2

At Cleator Moor.

Four-feet Band.

	Ft.	In.
COAL	1	3
Metal	0	9
COAL	2	3
	4	3

Five-feet Coal.

	Ft.	In.
COAL	3	0
Band	0	3
COAL	1	3
	4	6

Bannock Band.

	Ft.	In.
Rattler	0	6
COAL	3	0
Metal	1	4
COAL	4	0
	8	10

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The partings in the Ten-quarters Coal at Ellenborough are more numerous than in the Five-feet Coal of Cleator Moor, according to the above sections, but they are variable in the Ten-quarters Coal; for example, on the north side of the Ellenborough Colliery the aggregate thickness of the partings in the Ten-quarters Coal have been as much as 6 feet 6 inches, whilst on the south side of that colliery they are now only about 6 or 7 inches. In some parts of the district there is only one parting in the seam.

3.—The general succession of the seams and of the interbedded strata also demands the suggested alteration, as will be seen on reference to the detailed sections and also to Plate XXXIII.

The only piece of evidence which is against the new correlation is the *thickness* of the seams. For instance, the Bannock Band corresponds more nearly in thickness to the Ten-quarters Coal than it does to the Rattler Band, but that fact, unsupported by any other, is not of much value, because seams sometimes vary considerably in thickness, even in short distances; for example, the Five-feet Band of Cleator Moor, so-called from the fact of its there being on the average about five feet thick, is at Croft Pit, Whitehaven, only about a foot thick, and in the section of Wellington Pit, in the same colliery, it does not appear at all.

Having thus determined the correlation of the seams in the Lower Measures it becomes possible to ascertain the relation thereto of the Whitehaven Sandstone. That formation, like the Lower Measures, consists mainly of sandstones and shales, but in the Whitehaven Sandstone these rocks are generally of a purple-grey colour, although in some places they include light sandstones and also light and dark coloured shales such as prevail in the Lower Coal-measures, as will be seen on reference to the lower part of some of the detailed sections. Typical sections of the purple-grey sandstones of this formation may be seen in Bransty Cliffs, on the north side of Whitehaven, also in the upper part of Garlic Gill, near Dearham, and in the banks of the River Waver, near Bolton Low Houses. Among colliers of the district the purply-grey colour, which is characteristic of the Whitehaven Sandstone, is frequently called "brown," a fact which it is necessary to bear in mind in this investigation, as it is essential to a correct translation of the sections.

Referring now to the sections on Plate XXXIII., the unconformity of the two chief members of the Coal-measures will be seen at a glance, but its amount will be better understood by comparing the thickness of rocks interposed at different places between the base of the Whitehaven Sandstone and any seam of coal in the Lower Measures which is found

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in every part of the district. The seam which is best adapted for this purpose is that which goes by the name of the Yard Band at Cleator Moor, Maryport, Gilcrux, Dearham, Aspatria, and Mealsgate. The height above that seam, of the base of the Whitehaven Sandstone, at six different places in the field, is given below:—

	Fms.	Ft.	In.
Whinnyhill Pit, Cleator Moor	75	1	8
Croft Pit, Whitehaven	81	3	0
Ellenborough Pit. Maryport	93	3	6
Crosby Pit, Bullgill	64	4	0
No. 3 Pit, Aspatria	36	3	3
No. 2 Pit, Bolton	11	1	1

The unconformity is thus placed beyond doubt, but it is further illustrated in Plates XXXIV., XXXV., and XXXVI. It is also shown by the fact indicated on Plate XXXII., that at Rowrah and other places in that neighbourhood, the Whitehaven Sandstone rests directly on the Millstone Grit.

From the way in which the Whitehaven Sandstone cuts off, one after another, the upper seams of the Lower Coal-measures, it would appear that in the area extending eastward from High Hall toward Rose Castle only the very lowest seams in the field can exist in the Lower Coal-measures, although it is likely that the Crow Band and Master Band of Bolton will there exist in the Whitehaven Sandstone.

The development of the Whitehaven Sandstone is variable. In some parts of the district it consists, as at Rosegill for example, of purple-grey sandstone and shales, whilst at other places, as in the neighbourhood of Maryport and Bolton, it contains in its lower part a considerable thickness of light and dark coloured shales similar to those which form the bulk of the Lower Coal-measures, from which indeed they would be indistinguishable but for the fact that the purple-grey sandstones and shales come on below them. In these light and dark coloured shales there are a number of coal seams, but only two that have hitherto been considered worth working. In the Bolton district these seams are known as the Crow Band and the Master Band. At Aspatria, Bank-end Pit, they are called respectively the Crow Band and the Ten-quarters Coal. In the Ellenborough, Ewanrigg, and Flimby collieries both these seams exist, but only the upper one (the Crow Band of Bolton and Aspatria) has been worked. It is known in these collieries by three different names, the Yard Band, the Whitecroft seam, and the Senhouse High Band.*

* Since this was written the author has had an opportunity of perusing a paper on the West Cumberland Coal Trade, by the late Mr. Isaac Fletcher (Transactions of the Cumberland and Westmorland Antiquarian and Archæological Society, 1878), from which it appears that Mr. Fletcher also was of opinion that the Senhouse High Band was in the Whitehaven Sandstone, but he does not mention the Bolton and Aspatria seams in the same rocks.

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It is also probable that the Crow Coal of King Pit, in the Whitehaven Colliery, is the higher of these two seams, that is, the Crow Band of Bolton; but that is a mere conjecture, as there is no detailed section of the pit. The Whitehaven Sandstone, however, occupies the surface of the ground for some distance around King Pit, and, judging from its thickness in the sea brows to the westward, it probably extends farther down the shaft at King Pit than the position of the Crow Coal in the skeleton Seam-Section which has been preserved. Moreover, there is not a seam in the Lower Coal-measures in any other part of the field so far above the Main Band as this "Crow" Coal. The "Little" Band of King Pit is also likely to be in the Whitehaven Sandstone, and may be the correlative of the Master Band of Bolton and of the Ten-quarters Coal of Aspatria.

The areas occupied by the Whitehaven Sandstone and the Lower Coal-measures, immediately below the superficial deposits, in the district more especially under consideration, are shown in Fig. 1, Plate XXXII. It is, however, necessary to bear in mind that both formations pass in below the Permians, as shown in Section No. 1, Plate XXXIV.

The correlation of the seams in the different parts of the coal-field being now established, a few instances will be given of the variations in the thickness of the strata between corresponding beds at different places.

The Senhouse High Band in the Ellenborough Colliery is 17 fathoms 1 foot 11 inches above the base of the Whitehaven Sandstone. At No. 3 Pit, Aspatria, the corresponding seam is 25 fathoms above the base of the purple grey rocks, whilst at No. 2 Pit, Bolton Colliery, this thickness is increased to 33 fathoms. From this it is clear that there is a thickening of these beds in a north-easterly direction.

In the Lower Coal-measures it is also found that some of the beds increase in thickness towards the north-east, as for example the strata between the Cannel Band and the Yard Band as shown below:—

DEPTH FROM CANNEL BAND TO YARD BAND.

	Fms.	Ft.	Ins.
At Ellen Pit, Gilcrux	10	0	0
„ Bank End Pit, Aspatria	20	0	0
„ No. 3 Pit „	25	3	0
„ Mealsgate	28	3	2

This north-easterly thickening of the measures corresponds to that which is found in the sandy and shaly beds of the Carboniferous limestone, and which was pointed out by the author in his paper "On the Hæmatite Deposits of Furness."*

* Transactions of the Institute, Vol. XXXI., p. 211.

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Then again, at Whitehaven it is found that the measures lying between the Bannock Band and the Main Band thicken in the same direction as indicated hereunder:—

DEPTH FROM BANNOCK BAND TO MAIN BAND.

	Fms.	Ft.	Ins.
At St. Bees Borehole	9	0	0
„ Croft Pit	10	4	10
„ Kells „	12	3	4
„ Saltom „	13	3	0
„ King „	20	0	0
„ Wellington Pit	21	5	7

This thickening appears to cease somewhere near Wellington Pit, for at William Pit the two bands are only 20 fathoms apart. At Parton they are not so much. Then again, the Little Main Band and the Main Band of Workington, which correspond respectively to the Bannock Band and the Main Band of Whitehaven, are about 28 fathoms apart. Beyond Workington these seams are known as the Rattler Band and the Cannel and Metal Band respectively, and the distance between them decreases thence toward the north-east as the following statement will show:—

DEPTH FROM RATTLER BAND TO CANNEL BAND.

	Fms.	Ft.	Ins.
At Ellenborough Pit, Maryport	21	2	4
„ Crosby Pit, Bullgill	19	4	4
„ Ellen „ „	17	5	8

There also appears to be a thickening of the measures westward in some parts of the field, for example, the depth from the Main Band to to the Low Bottom Band at Cleator Moor is 39 fathoms 4 feet, whilst at Wellington Pit, Whitehaven, the depth between the same seams is 43 fathoms 2 feet 9 inches. Then again at Greysouthen there is 41 fathoms 5 feet 5 inches between those seams, and at Workington 52 fathoms 3 feet.

Between some of the other seams there are similar variations in the thickness of strata.

In connection with this subject it is curious to notice the relative proportion of sandstone and shale in the strata of different parts of the field. The following statement exhibits these proportions in the measures between the Ten-quarters Coal and the Yard Band at Maryport and at Bullgill, and also between the corresponding seams at Whitehaven:—

	Aggregate Thickness. Of Sandstone. Fms.	Ft.	Ins.	Of Shale. Fms.	Ft.	Ins.	Total Thickness Between the Seams. Fms.	Ft.	Ins.	Proportion of Sandstone.
At Wellington Pit, Whitehaven	17	4	6	20	3	10	38	2	4	46
„ Ellenborough Pit, Maryport	15	1	7	23	5	6	39	1	1	·35
„ Ellen Pit, Bullgill ...	5	1	3	28	3	9	33	5	0	·15

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The last column shows the proportion of sandstone to the total thickness of strata between the two seams. It therefore appears that both the actual quantity of sandstone, and also the proportion it bears to the total thickness of strata lying between the two seams mentioned, becomes less and less toward the north-east.

It may also be observed that in any part of the field the proportion of sandstone is greatest in the upper and lower part of the measures, the central portion, where the principal coal seams are found, consisting mainly of shales, the proportion of which decreases both upward and downward as the sandstone increases. The only exception to this, if an exception it can be called, is the Main Band Stone at Whitehaven and Cleator Moor, etc.

THICKNESS OF STRATA.

The Lower Coal-measures are best developed at Maryport and Cleator Moor, but they are thickest at Workington. From the bottom of the Whitehaven Sandstone to the Main Band at St. Helens new pit is 92 fathoms or thereabout. In the old Workington Colliery the Hamilton Band was proved to be about 52½ fathoms below the Main Band. In Harrington Colliery the mountain limestone was pierced by John Pit at a depth of 96 fathoms below the Three-feet Band, which, evidently, is the same seam as the Hamilton Band of Workington, so that if an allowance be made for the Millstone Grit, and assuming that there is no difference in the thickness of the strata between the Three-feet Band and the Millstone Grit at Harrington, and between the Hamilton Band and the Millstone Grit at Workington, the total thickness of the Lower Coal-measures at Workington will be about 1,300 feet.

Between Ellenborough Pit and Risehow Old Pit the Whitehaven Sandstone was pierced by a shaft 50 fathoms deep, and from the bottom of that shaft a borehole was put down 58 fathoms 1 foot 4 inches without reaching the Senhouse High Band, which, however, judging from other sections in the neighbourhood, could not be more than four or five fathoms further. The thickness of the Whitehaven Sandstone there, may therefore be considered to be about 750 feet. In the neighbourhood of Mealsgate the Whitehaven Sandstone, above the Senhouse High Band, has been proved by boring to be certainly 578 feet thick. Below the Senhouse High Band the thickness of those rocks has been ascertained by other boreholes and shafts put down in that neighbourhood to be about 200 feet, so that the greatest known thickness of the Upper Coal Formation in the Bolton district is about 778 feet.

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Taking the Lower Coal-measures at Workington and the Upper Coal-measures at Mealsgate, the greatest ascertained total thickness of the Coal-measures may be set down at about 2,078 feet, as below :—

	Feet.
Whitehaven sandstone	778
Lower Coal-measures	1,300
Total	2,078

As, however, all these depths are taken at some distance from the full dip of the field it is quite possible, and in fact very probable, that both the upper and lower formation have a greater total thickness than has yet been proved.

COAL SEAMS.

In taking a general sectional view of the Coal-measures from top to bottom, one of the first points which strikes an observer is the manner in which the main seams of coal are placed, so to speak, in the central part of the mass. Although the measures have a total thickness of over 2,000 feet, yet the whole of the workable seams are included in about 1,200 feet of them, there being barren ground, in the sense that it does not contain any seams that are workable, both above and below. In this thickness there are twelve principal seams, having in the aggregate about 50 feet of workable coal, exclusive of the metals that occur in them. The greatest thickness of coal in the Lower Measures is at Cleator Moor. Below is a statement of the thickness, exclusive of metals, of the seven principal seams at Ellenborough and at Cleator Moor :—

Ellenborough.	Ft.	In.	Cleator Moor.	Ft.	In.
Hamilton Band	4	0			
Virgin Seam	2	6	Six-feet Seam	4	7
White Metal Seam	2	8	Four-feet Seam	3	6
Ten-quarter Coal	7	4	Five-feet Seam	4	3
Rattler Band	3	1	Bannock Band	7	4
Crow Coal and Cannel and Metal Band	9	10	Main Band	10	6
Yard Band	2	3	Yard Band	2	8
			Low Bottom	2	10
	31	8		35	8

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The most important seam in the district is that which is known at Cleator Moor, Whitehaven, and Workington as the Main Band. A section of it, as developed at Whitehaven and Cleator Moor, is as follows:—

Whitehaven.	Ft.	In.	Cleator Moor.	Ft.	In.
COAL	0	6	COAL { left on } ...	0	4
Cash	1	0	Metal { for roof } ...	1	0
COAL	1	8	COAL, brassy	2	0
Metal	0	2	Cash	0	2
COAL	3	4	COAL	9	0
Metal	0	2			
COAL	3	9			
	10	7		12	6

North of Workington the metals of this seam begin to increase in thickness, so that at Risehow and Ellenborough Pits it forms three distinct seams of coal, which are known as the Crow Coal, the Metal Band, and the Cannel Band. The Crow Coal and the Metal Band are close together, but the Metal Band and the Cannel Band are separated, at the latter colliery, by about four fathoms of metals. At Crosby Pit, Bullgill, these seams, the upper one being there called the "Thirty-inch" Coal, are slightly nearer together than at Ellenborough, but beyond Bullgill, in the direction of Bolton, they open out again, so that at Aspatria the Thirty-inch Seam and the Cannel Band are about ten fathoms apart (see Plate XXXIII.) The metals separating these seams also thicken toward the west, for on reference to the same Plate it will be seen that the Cannel and Metal bands are much farther apart at Ellenborough than they are at Broughton Moor, whilst at Dearham they are so close together that they may be looked upon as one seam. As the intermediate metals thicken toward the north-east the quantity of coal in the seams becomes less and less as shown below:—

Aggregate Thickness of Coal in the Crow Band and in the Cannel and Metal Bands.

	Ft.	In.
At Ellenborough Pit	9	10
„ Crosby Pit	9	7
„ Aspatria	4	11
„ Mealsgate	4	6

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There is here evidence of the *thinning* of a coal seam in a north-easterly direction, but in the Yard Band the evidence indicates a *thickening* in that direction, as shown below:—

THICKNESS OF YARD BAND.

	Ft.	In.
At Ellenborough, Maryport...	2	3
„ West Pit, Aspatria	3	0
„ No. 3 Pit, Aspatria	4	9
„ Bolton No. 2 Pit	5	6

Some of the seams appear to thicken toward the west, as for example the Six-quarters Coal. At No. 2 Pit, Cleator Moor, that seam is only about 3 feet thick, whilst at Wellington Pit, Whitehaven, it is 7 feet 7 inches. Then again at Melgramfitz Pit it is only 2 feet 11 inches, whilst at Jane Pit, Workington, it is 6 feet 5 inches.

Sections of some of the seams have already been given, others are as follows:—

YARD OR MAIN BAND OF BOLTON.

	Ft.	In.
COAL	1	2
Black stone	0	4*
COAL	1	8
Parting		—
COAL	1	7½
Black stone	0	1*
COAL	0	7½
	5	6

MASTER BAND OF BOLTON.

	Ft.	In.
COAL	1	6
Band	0	3
COAL	1	6
Band	0	4
COAL	1	7
	5	2

LICKBANK SEAM OF GREYSOUTHEN.

	Ft.	In
COAL	2	2
White metal	0	8
Black metal	0	2
COAL, inferior	0	9
Black metal	0	2
COAL, inferior	0	11
	4	10

LITTLE MAIN BAND OF BULLGILL.

	Ft.	In.
Rattler	0	4
COAL	1	10
	2	2

SIX FEET SEAM OF CLEATOR MOOR.

COAL (with ½ inch parting)	3	0
Black metal	1	8
COAL	1	8
	6	4

* These stone bands disappear in the direction of Gilcrux, where this seam is about 3 feet thick, and clean coal.

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Occasionally the coal seams alter into what is known as "stone coal." The seam continues of its full thickness, but it changes in mineral character, a great part of the bituminous matter giving place to siliceous and aluminous materials. A curious case of this kind occurred in the Crummock Colliery.† Similar alterations have been met with at Aspatria West Pit and elsewhere in the district.

Another kind of interference to which the seams are liable is known as a "nip." The coal in such cases becoming greatly reduced in thickness, or perhaps disappearing altogether. In the Main Band some very extensive "nips" have been met with, especially near Isabella Pit, Workington, at Camerton Pit, and at Greysouthen. It is not improbable that these nips are parts of one great nip which originally had a direction corresponding very nearly with that of the Derwent Valley.

FAULTS.

The field is intersected by an immense number of faults, some of which are very large. The most important are shown on Plate XXXII., Fig. 1, and also in the Sections Plates XXXIV., XXXV., and XXXVI. They may be divided into two sets; one set having a direction nearly east and west, the other bearing nearly north and south. As in other similar areas the throw of these faults is exceedingly variable, so that it is no uncommon thing to find a dislocation of 40 or 50 fathoms dying out altogether within a quarter of a mile.

Faults having an Easterly and Westerly Direction.—The largest of these, of which the throw has been determined, is that which separates the Cleator Moor coal-field from the Hæmatite areas of Cleator, *Aa*, Section 1, Plate XXXIV. At Mr. Stirling's No. 4 Pit this fault has a throw of about 200 fathoms. Parallel to it there is another very large fault passing through the estates of Birks and Mowbray. Both of them are up to the south.

A little south of Wreah Pit there is a large fault, up to the north, which passes along the valley traversed by Dub Beck.

A large fault, down to the north, and of an unascertained extent, passes by Maryport, Crosby, Aspatria, and High Blaithwaite, in the Parish of Bolton. This fault puts in the St. Bees Sandstone, which bounds that part of the known coal-field. See *Cc*, Section No. 2, Plate XXXV.; *Dd*, Section No. 4, Plate XXXIV.; *Ee*, Section No. 5, and *Ff*, Section No. 6, Plate XXXVI.

† "Notes on a Singular Transformation of the Seams of Coal into Stone at Crummock Colliery." By Williamson Peile. Trans. Nat. His. Soc. Northumberland and Durham, Vol. II., pp. 178-180.

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Another large fault, also down to the north, exists on the opposite side of that part of the coal-field. It runs from near Dearham Station by Gilcrux to High Hall, near Bolton New Houses. The throw of this fault, at Rosegill Pit, is about 170 fathoms, *Gg*, Section No. 3, Plate XXXV.; see also *Hh*, Section No. 4, Plate XXXIV.; *Ii*, Section No. 5, and *Jj*, Section No. 6, Plate XXXVI.

FAULTS HAVING A NORTHERLY AND SOUTHERLY DIRECTION.—A large fault having this direction passes through Bigrigg, putting the carboniferous limestone there into horizontal contact with the St. Bees Sandstone.

The Overend limestone is separated from the St. Bees Sandstone, which lies to the eastward, by an extensive fault having this direction, see *Kk*, Section No. 1, Plate XXXIV. Both these faults are up to the west.

From Micklam Point inland by Bonny there exists a large fault, up to the east, which at Micklam Pit has a throw of about 125 fathoms, *Ll*, Section No. 7, Plate XXXVI. This fault throws out the Main Band on the east and brings up the carboniferous limestone to within 92 fathoms of the surface at Micklam Pit. By a parallel fault, also up to the east, the Distington limestone is brought to the surface, *Mm*, Section No. 7, Plate XXXVI.

Most of the other faults in this direction are up to the *west*. A large one exists on the east of Old Risehow Colliery. Its throw is there about 180 fathoms. Another large one lies on the west side of Dearham Colliery, and there are a number of others passing from the hæmatite fields of Cleator and Frizington northward into the coal-field.

Many more of less importance exist between Gilcrux and Bolton, they are less extensive than those already mentioned, but they are all shown on Plate XXXII., so that they need not be particularly described here.

Some of the east and west faults do not pass up through the Permians, notably the large fault which separates the Cleator Moor coal-field from the adjacent hæmatite area. This fault appears to have existed even before the Whitehaven sandstone was deposited, as that formation does not seem to be intersected by it. Most of the large north and south faults have had a movement since Permian times, although they are probably of pre-Permian origin.

DIP OF STRATA.

The general dip of the Coal-measures is westward, but there are a few exceptions. At Bolton the dip is northward. At Aspatria Old West Pit it is towards the east. The Crosby and Gilcrux collieries are in a sort of trough, on one side of which the measures dip westward, whilst on the other they incline towards the east.

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The strata at Dearham form half a basin, so that on the north side the measures have a southerly dip, on the east they incline westward, and on the south side they dip northward.

At Workington the measures dip northward, whilst in the Harrington Colliery the dip is eastward.

Under the sea there are also exceptions to the general dip. At Whitehaven Colliery, in the direction of Parton, the measures incline toward the east. So they do at Micklam Pit. This easterly dip will doubtless prevent a large quantity of coal being wrought under the sea, as the seams, unless thrown down by a succession of faults, will eventually crop out on the sea bottom, and the working must necessarily stop some distance short of the outcrop. In the principal part of the area worked under the sea at Whitehaven the dip is normal, that is westward, so that the cover increases in thickness as the workings are pushed seaward.

The amount of dip, both inland and under the sea, is variable, being in some places so gentle as almost to appear level, whilst in other cases the rocks are inclined at an angle of 1 in 3. The average dip is probably about 1 in 5 or 1 in 6.

EFFECTS OF FAULTING, TILTING, AND DENUDATION.

One of the principal results of the combined action of these three operations is the great variation in depth at which the various seams are found in different parts of the district. For example, on Broughton Moor the Cannel and Metal Bands, over a large area, are quite near the surface, whilst at Maryport they are at a depth of about 140 fathoms. These variations will however be better understood by reference to the longitudinal sections herewith than by any amount of written description.

Another result of the first importance arising from these causes is the diminished area of the coal-seams as compared with their extent originally. As invariably happens the upper seams have suffered most, but some of the lower seams have also been denuded over extensive areas. The Main Band, for instance, is absent throughout an area of about 30 square miles, that is for about one-third of the extent of the coal-field.

One of the most curious effects of these operations is the triangular piece of ground worked by the Crosby and Gilcrux collieries, which has an area of about three-quarters of a square mile. It contains all the seams in the field, from the Ten-quarters downwards, and also, in places, some of those above that seam. It is bounded by three great faults, one of them being that which puts in the Permians on the north. The throw of that fault has not yet been ascertained, but it is doubtless great. The

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other two faults have each a throw of about 170 fathoms or thereabout. One of these separates the triangular area from the Dearham district, and the other cuts off that of Aspatria. Both of them throw out all the more important coal-seams, as shown in Section No. 3, Plate XXXV., so that there is no workable ground of any value for some distance from these faults on the upside of them.

In connection with this subject the small limestone areas of Distington and Overend may be mentioned. The exposure of this rock over such limited areas almost in the very heart of the coal-field is interesting, as showing the enormous amount of denudation that has been effected, and also how faults of great throw are sometimes of small extent longitudinally.

Another point worthy of notice is the absence of Whitehaven Sandstone over a large belt of ground extending from the sea coast between Parton and Workington to the outcrop of the coal-field between Ullock and Dovenby. This seems to be a continuation of the great east and west anticlinal which passes through Skiddaw, and to have resulted from the same, or at any rate some of the same series of upward movements. The removal of St. Bees Sandstone from a large part of the known coal-field between Maryport, Bullgill, Cleator, and Whitehaven is doubtless due to the same cause, combined, of course, as in the case of the removal of the Whitehaven Sandstone, with denudation.

SUB-PERMIAN AND SUB-MARINE EXTENSION.

By reference to the section of Whitehaven Colliery in Plate XXXIV., it will be seen that the Coal-measures have been proved to extend for a considerable distance in below the Permians. In fact they have been very extensively worked under those rocks. The borehole at St. Bees proved them to extend so far under the Permians, but south of St. Bees, their existence is a speculative matter. There is no positive data to work upon. If the great fault which throws out the Cleator Moor coal-field on the south extends as far westward as is shown on Plate XXXII., the Whitehaven coal-field will also be terminated by it, and the Coal-measures on the south side of that fault will be shifted a long way seaward. In any case, however, it seems probable that the Bannock Band and Main Band will gradually approach one another toward the south, and eventually form one large seam.

In the area occupied by the Permians north of the great fault, extending from Maryport by Aspatria to High Blaithwaite, the existence of the Coal-measures has not yet been proved, but there can be no doubt that they do exist. The only point about which there can be any doubt

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is the depth at which they will be found. For the purpose of settling this point a borehole was put down in the quarry near Allerby Hall on the north or down side of the fault. It passed through the Permians, and also through the Whitehaven Sandstone, reaching the Lower Coal-measures at a depth of 53 fathoms 1 foot 6 inches, but it appears to have been too near the fault, and consequently to have passed through it into the rocks on the up side. The Whitehaven Sandstone on the up side has been proved to have a thickness of 50 fathoms near the Maryport and Carlisle Railway, east of Bullgill station, and it is probably much thicker to the northward over the centre of the trough in the Lower Coal-measures. The rocks thence rising toward the great fault will probably reduce the thickness of the Whitehaven Sandstone until it is again about 50 fathoms, adjoining the fault on the south, so that the borehole in Allerby Quarry must have passed through the fault. Another attempt to get into the coals beyond this fault was made at Ellenborough Colliery, Maryport, a few years ago. From the Ten-quarters Seam, at a depth of 120 fathoms from the surface, a drift was put through the fault for about 21 feet, but it only met with red sandstone, probably Whitehaven Sandstone. There does not appear to have been a borehole put down from that drift, nor any means taken to ascertain the position of the Lower Coal-measures below, so that beyond fixing the minimum amount of "throw," the exploration proved very little. The question may therefore be regarded as still unsettled. But it may be safely said that, whatever is the depth of the Lower Coal-measures just over the fault, that depth will be greatly increased toward the dip. It is known that at Mealsgate the Whitehaven Sandstone is certainly close upon 800 feet thick, and there is reason to suppose that it will be very much thicker below the Permians to the north, for, as will be seen on reference to Section No. 6, Plate XXXVI., it increases in thickness rapidly toward the dip. A borehole put down in Kelswick Moss, near Abbey Town, proved the Upper Gypseous Shales to extend to a depth of 933 feet. Below these shales came the St. Bees Sandstone, until 1,020 feet was reached, when the bore was stopped. The total thickness of the St. Bees Sandstone there will probably be several hundred feet. Then the Whitehaven Sandstone has to be pierced, so that altogether it is likely that at Abbey Town the Lower Coal-measures will not be reached at a less depth than about 2,000 feet.

When the Coal-measures have been proved under these Permian rocks there will still remain one very important matter to settle, and that is their extent. How far they continue under the sea or in the direction of

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Canobie is a matter of mere speculation at present, and can only be settled by the borer and miner. But it would appear from the way in which the Whitehaven Sandstone cuts off, one after another, the seams in the lower measures between Maryport and Bolton Low Houses, that the coal-field cannot extend farther than Carlisle, under the Permians, until all the more important seams are cut out altogether. At Maryport the base of the Whitehaven Sandstone is 93 fathoms above the Yard Band, and at Mealsgate it is only 11 fathoms above that seam, so that if the unconformity thus indicated continues, the Yard Band will soon disappear, as the seams above it have gone before; and then in succession will be cut off the Six-quarters Band and the seams corresponding to the Four-feet Coal and the Udale Band of Harrington. The Canobie coal-field, according to Professor Geikie, is very much lower in the Carboniferous system than the true Coal-measures, so that the existence of that small patch of coal-bearing strata, contrary to the supposition of Dunn and others, affords no evidence whatever of the north-easterly extension of the Cumberland Coal-field.

How far the coal-field may extend *northward* under the Permians of the Solway, it is impossible to say, it is only known at present that as the lower measures approach the great fault which puts in the Permians they increase in thickness, the overlying Whitehaven Sandstone occurring at a less angle than the Lower Coal-measures, so that higher and higher seams appear in these latter rocks the nearer the dip is approached.

It is probable that the seams will be further apart under the Permians north of Aspatria and Bolton than they are in the known coal-field, and it is almost certain that some of them, notably the Cannel and Metal Bands, will be so small as to be unworkable.

In the direction of the Isle of Man there is also very little information. The most that can at present be said is that as far as the workings of the Whitehaven colliery under the sea have yet been prosecuted the strata still dip westward. Before the Coal-measures disappear it is probable that this dip will gradually become less and less until the strata are level. Then they will most likely rise toward the east, and either crop out at the sea bottom in the direction of the Isle of Man, where it is known that Lower Carboniferous rocks exist; or the coal-field might be suddenly cut off by a large fault, as at Cleator Moor.

Much more might be said on this subject, but wanting a sufficient foundation of fact the superstructure could only be regarded with suspicion.

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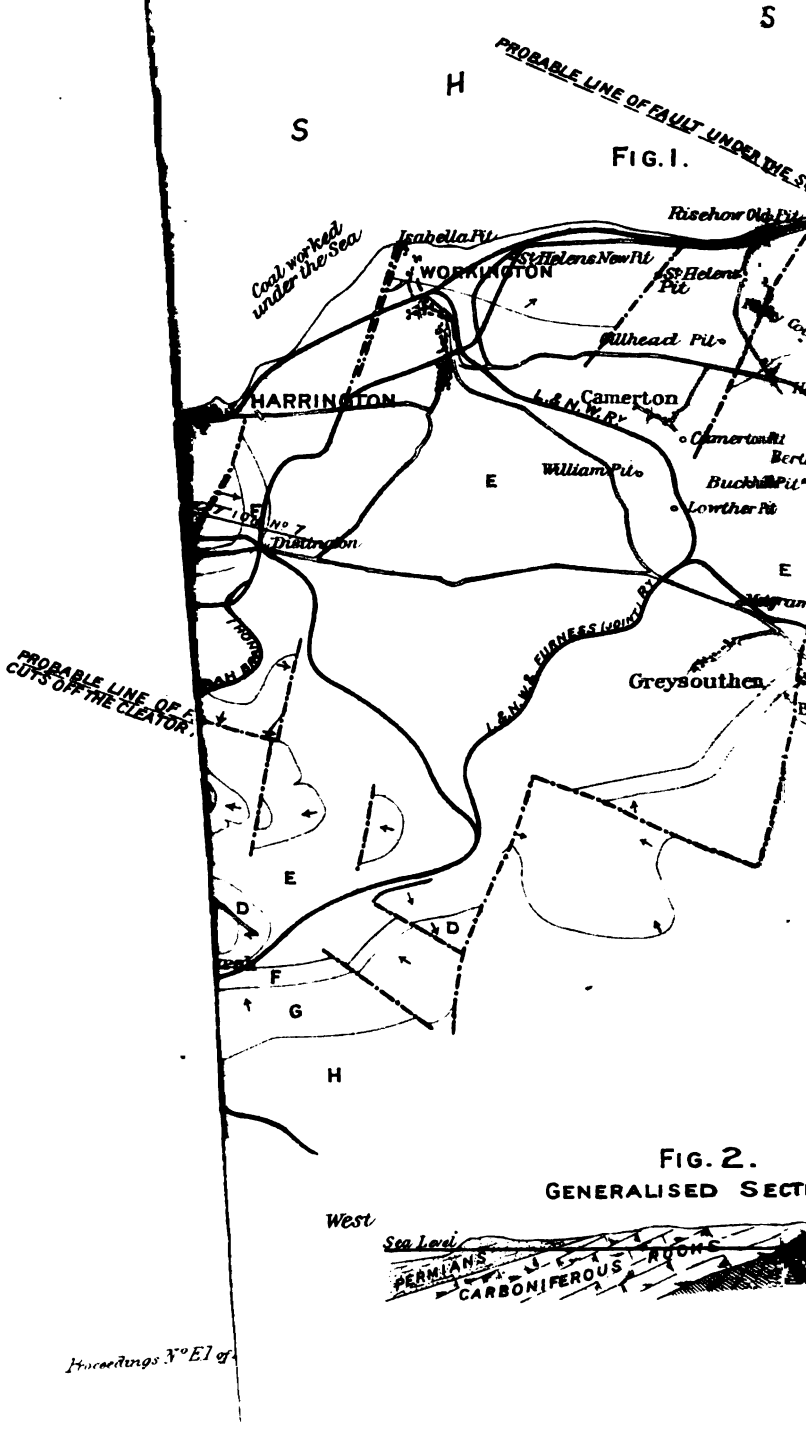

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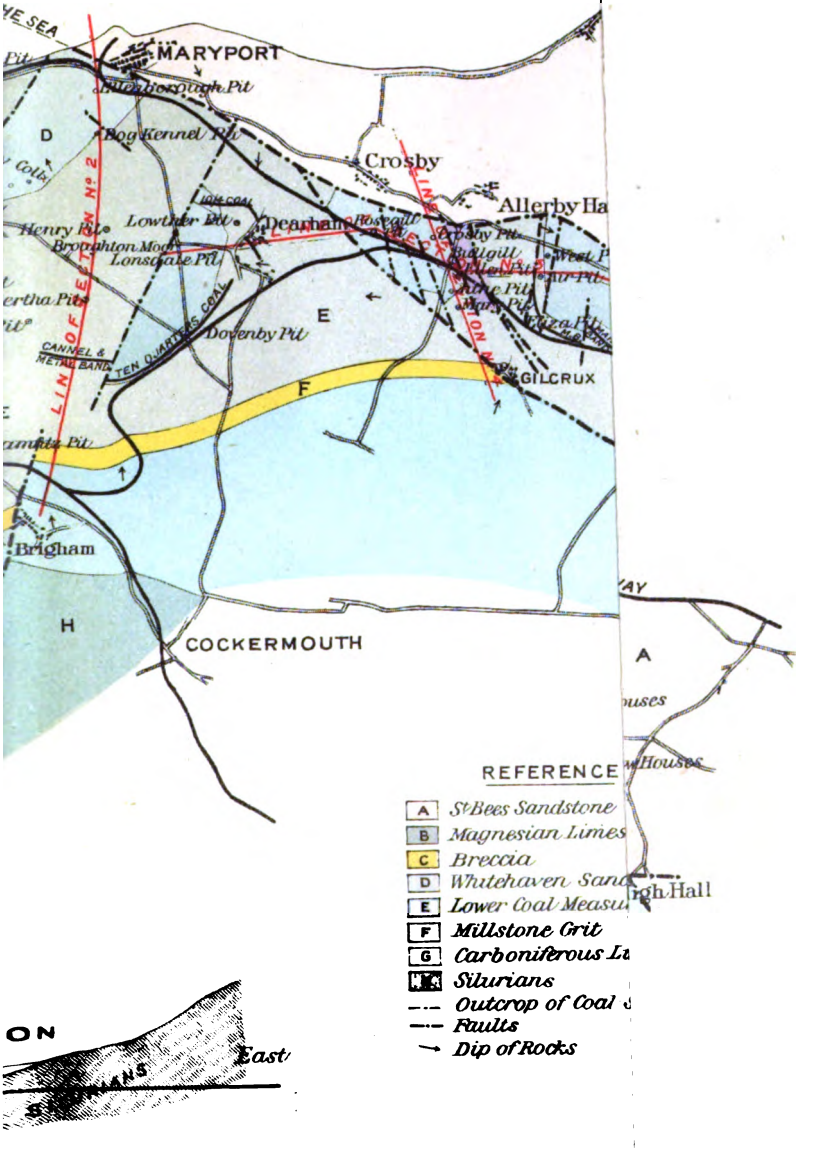

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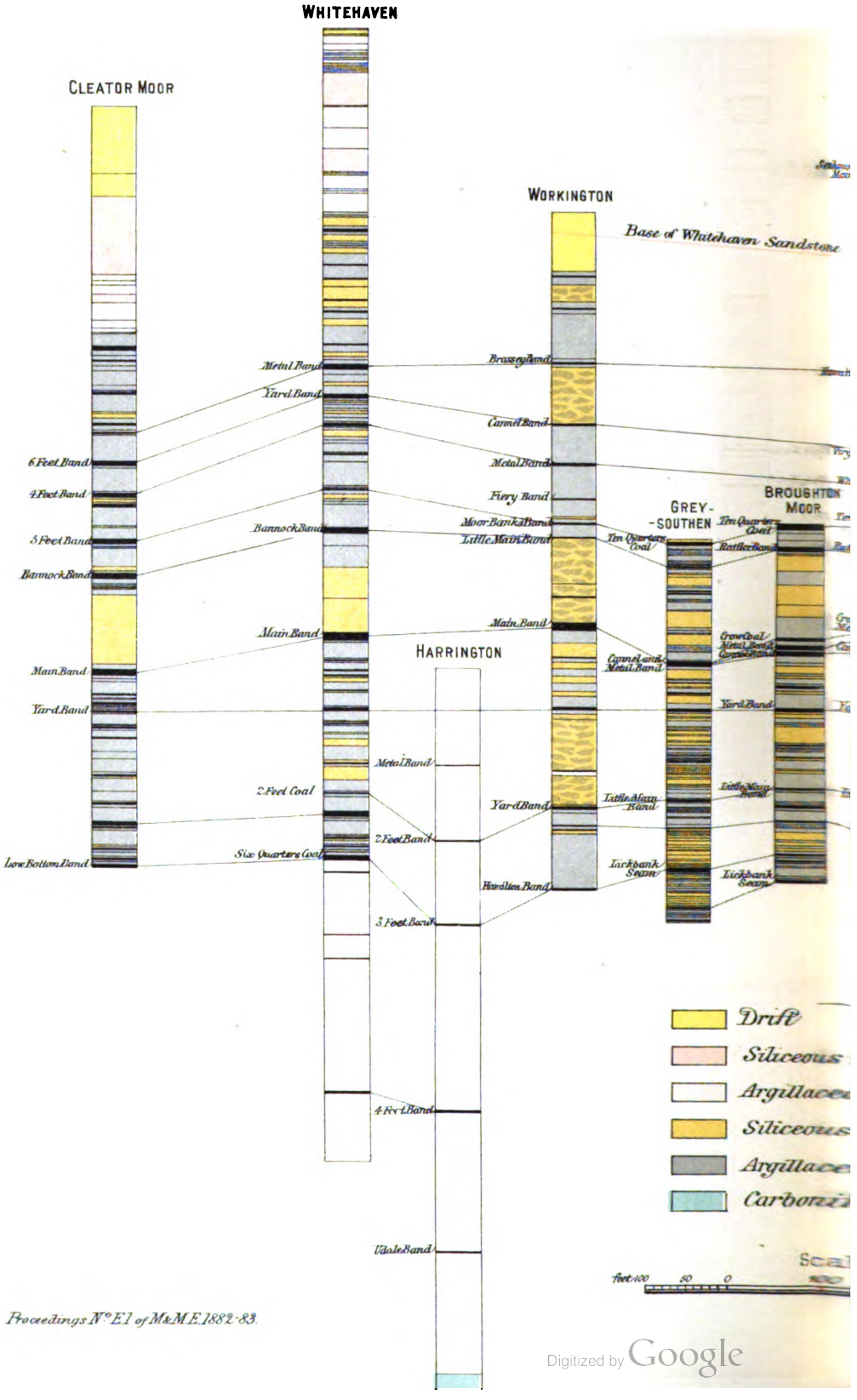

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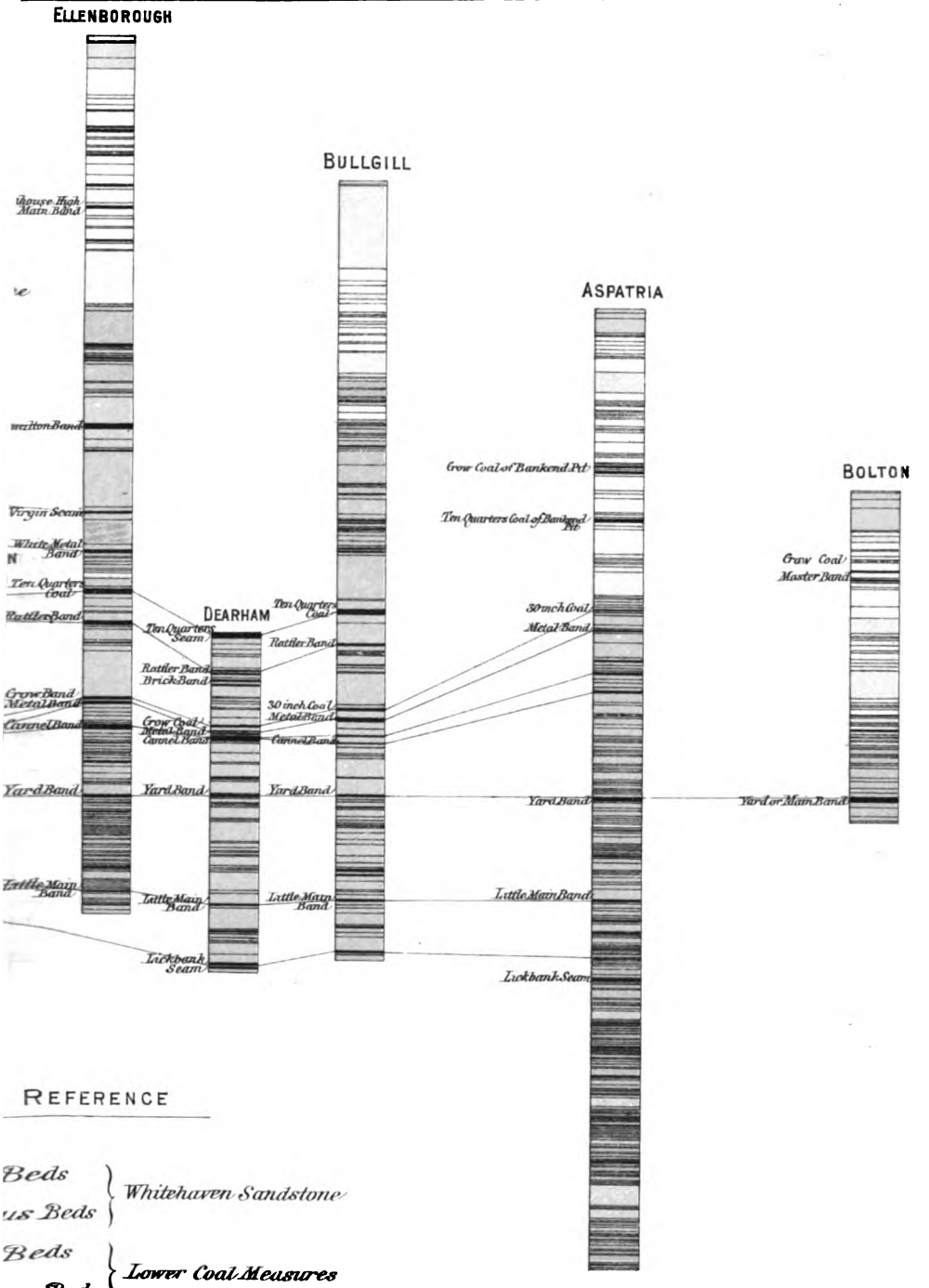

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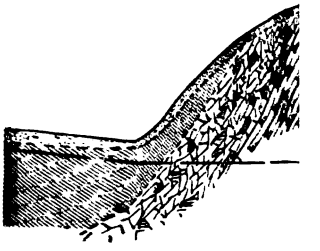

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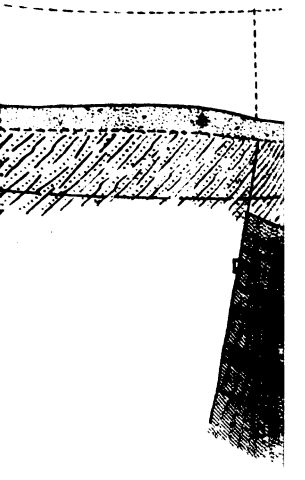

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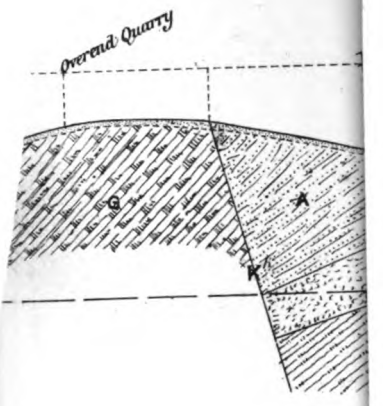

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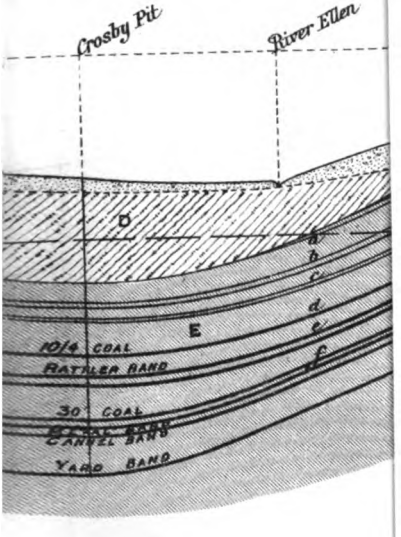

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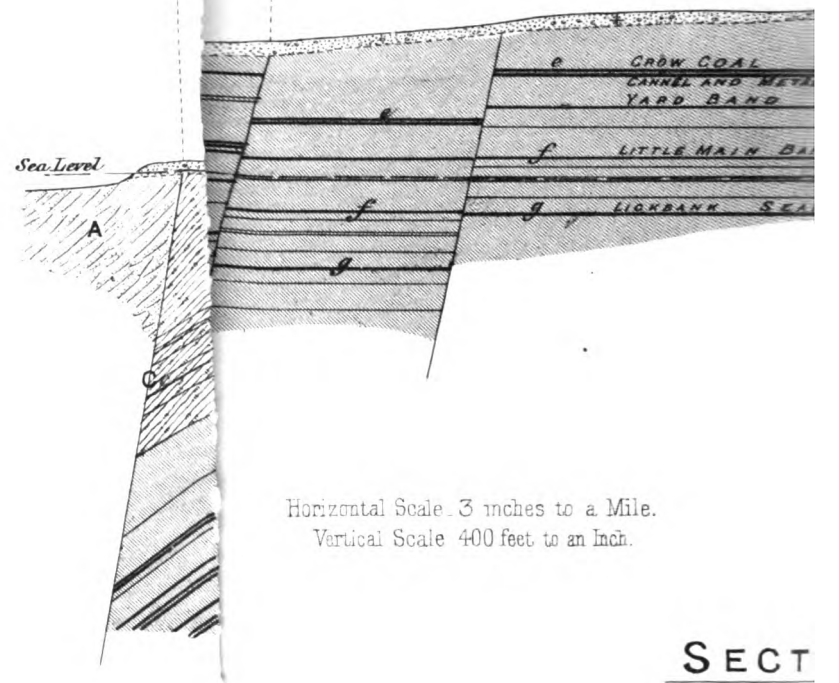

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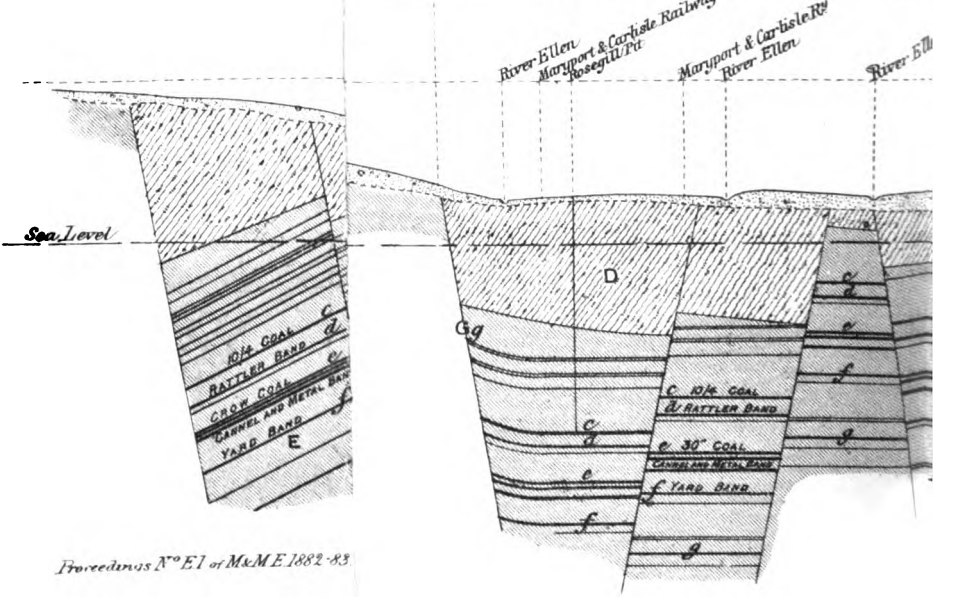

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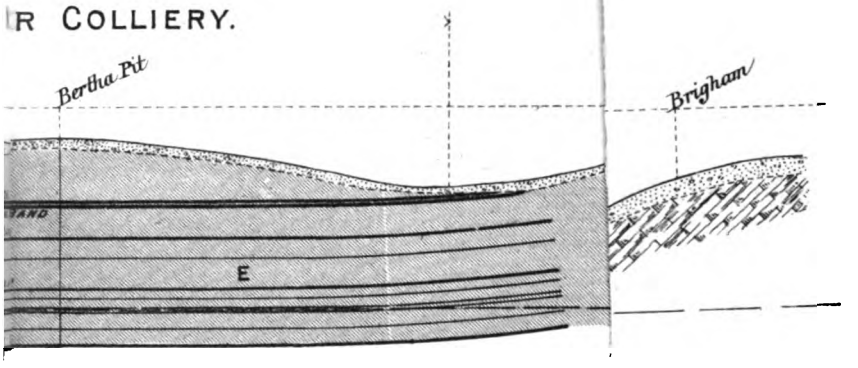

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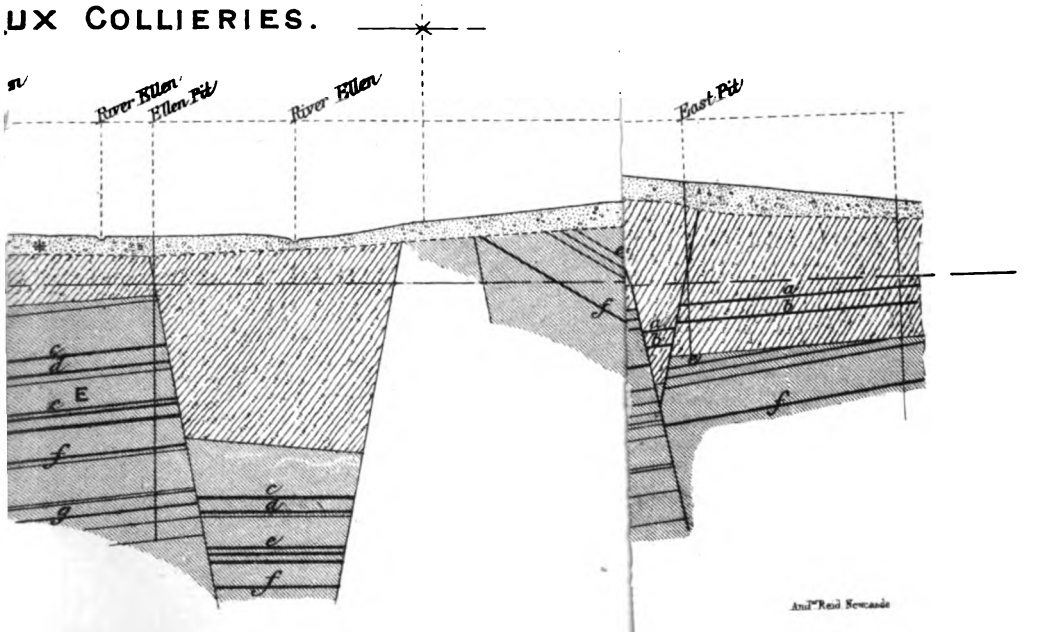

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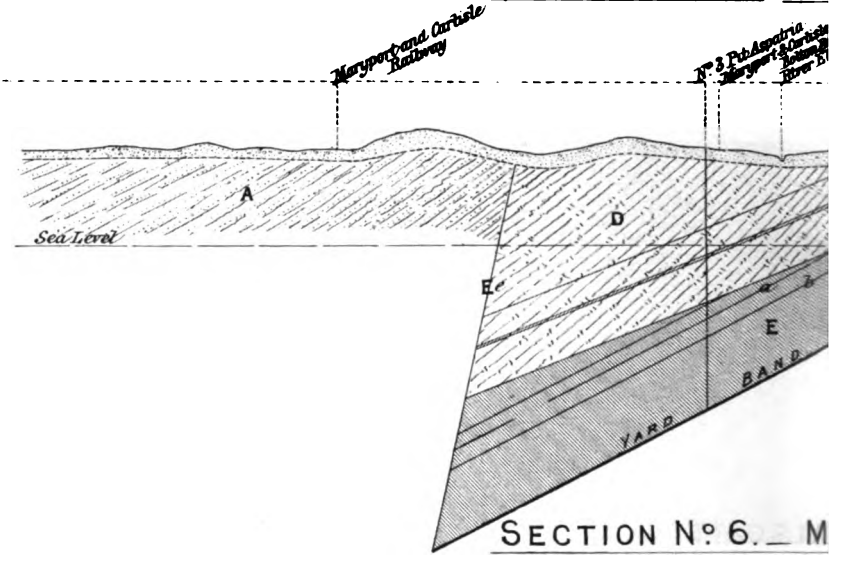

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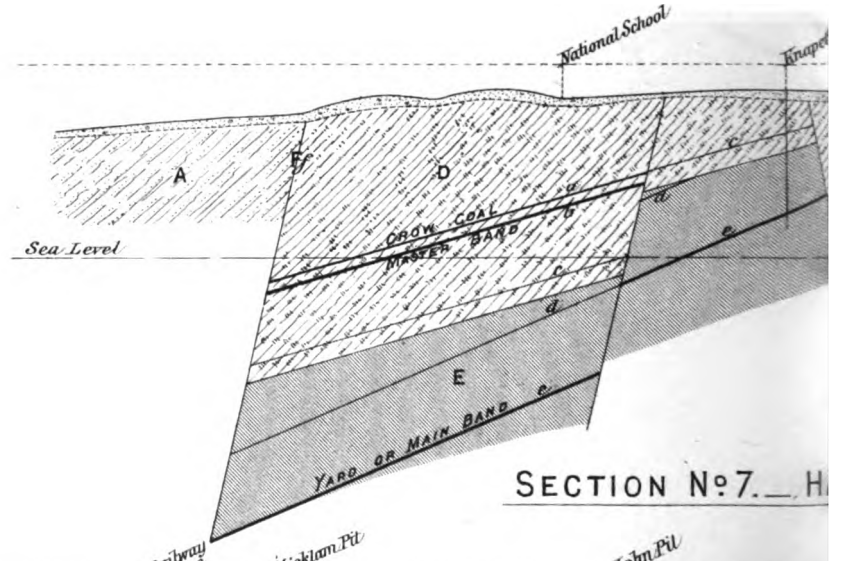

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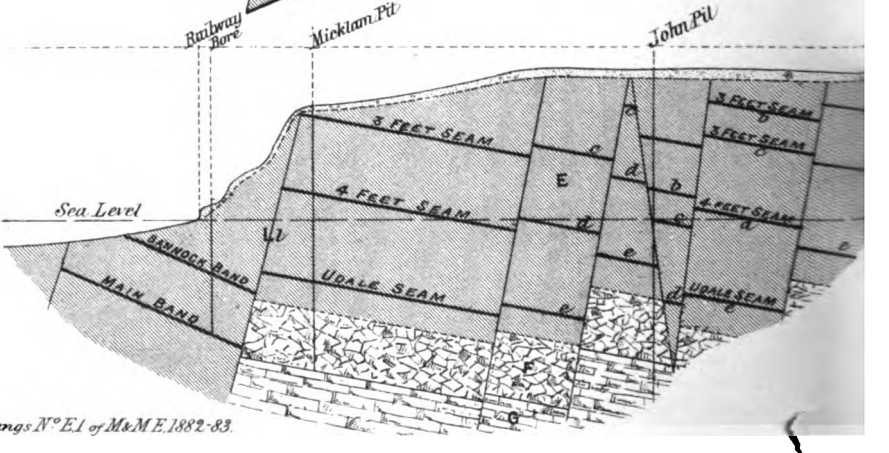

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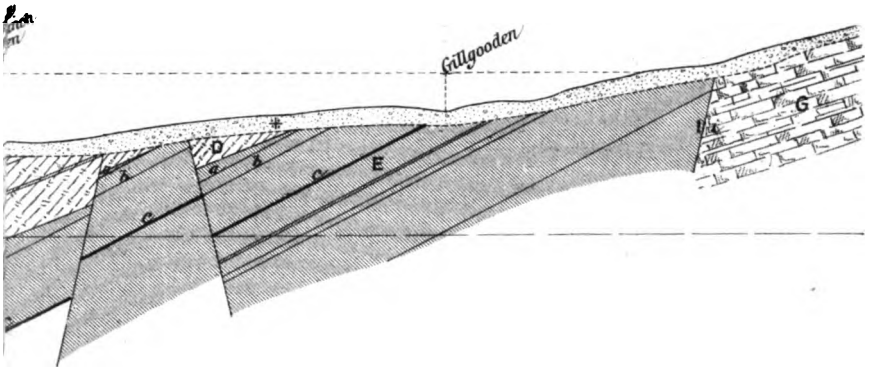

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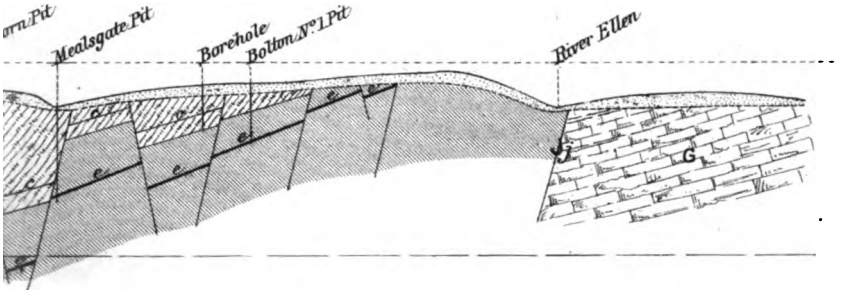

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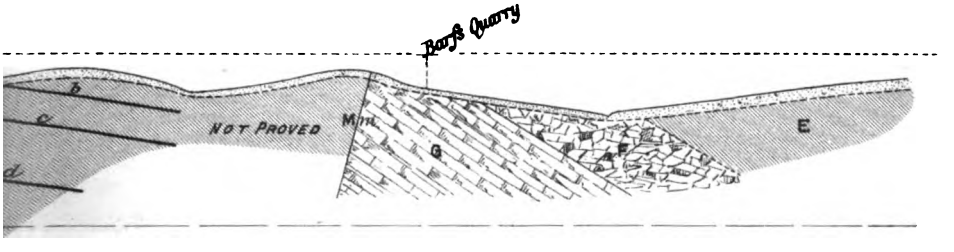

REFERENCE

- *Superficial Deposits*
- *St. Bees Sandstone*
- *Whitehaven Sandstone*
- *Lower Coal Measures*
- *Millstone Grit*
- *Carboniferous Limestones*

Horizontal Scale, 3 inches to a Mile
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The PRESIDENT said, he was sure every one of the members must feel very much obliged to Mr. Kendall for having presented such a valuable and interesting paper to the institute, more especially as they were to pay a visit on Friday to a portion of the coal-field described. He would be very glad to hear any observations anyone might wish to make on the subject of the paper, and any explanations required would be readily given by Mr. Kendall. As having a bearing on the same subject, he also begged to call attention to the paper that was to follow on "The Earl of Lonsdale's Mines at Whitehaven," by Mr. G. H. Liddell, and there was also down for discussion a former paper of Mr. Kendall's on "The Hæmatite Deposits of Furness."

Mr. KENDALL said, with reference to the last-mentioned paper, they would see he had produced for inspection a number of carboniferous fossils in pure hæmatite, also a number of thin sections of hæmatite, which, he had no doubt, would prove very interesting to them on examination through the microscope.

Mr. W. H. HEDLEY, in opening the discussion on Mr. Kendall's paper on "The Cumberland Coal-field," asked if the throw of the fault running from Maryport towards Aspatria had been definitely proved?

Mr. KENDALL explained, from the sections produced, the nature and extent of the fault, and added that the bore-hole put down in Kelswick Moss to a depth of 1,020 feet passed through the red rocks and stopped there, without the coal-measures being found; and the other bore, made for a depth of 65 fathoms, passed through the Permians, but it was too near the fault which brought those into horizontal contact with the coal measures to definitely settle the question of the depth to which the coal-field was thrown down. He had no doubt, however, that the coal-measures were to be found in the area occupied by the Permians north of the fault referred to.

Mr. HEDLEY said, Mr. Kendall had shown it was a dip fault, and that being so there must be some coal to the north of the fault, under the Permians.

Mr. KENDALL replied, that undoubtedly that was the case.

Mr. T. P. MARTIN said he was glad this paper had been read by Mr. Kendall. The Cumberland Coal-field was admitted on all hands to be a difficult one to work; and it had been felt by those connected with the collieries in West Cumberland, and especially by strangers, that there was a great dearth of reliable information as to the nature of the field and the relationship of the seam in different localities. The paper just read

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supplied a large amount of the information required, and it would, no doubt, be the means of bringing to light more, and classifying it into useful form. Another value to be attached to the paper was that it would probably assist in the establishment of the Institute in that district. The subject was one of peculiar local interest, and he would like to suggest that the paper be discussed at a meeting of local members either at Workington or Whitehaven. He did not wish to ask for Home Rule altogether, but he certainly thought it would be a good thing if they had a meeting or two in that district, as it was not always possible or convenient for local members to travel so far as Newcastle. It would be almost impossible to discuss the paper at any length until it was in the hands of members in a printed form, so that they might look carefully through it and hunt up further data on the subject to see how it compares with what Mr. Kendall had stated. With reference to Mr. Kendall's opinion that the Bannock Band of Whitehaven was the same seam as the Rattler Band of the Clifton and Maryport districts, he believed that it was the view expressed many years ago by the late Mr. Isaac Fletcher, a gentleman intimately acquainted with the Cumberland Coal-field, and the statements made by Mr. Kendall appeared to strengthen this view. With respect to Mr. Kendall's remarks on the unconformity of the Whitehaven sandstone, there appeared, from the information brought forward, to be room for doubt on the point. It would be noticed from the diagrams that the idea was to prove the unconformity by its distance above certain seams of coal in different localities; but so long as the question rested on the co-relation of seams in this way the evidence was to some extent unsatisfactory. In a paper read by the late Mr. Isaac Fletcher before the Archæological Society, some years ago, he endeavoured to prove its unconformity by its distance above the Six-quarter Seam at Whitehaven, and the distance above the seam worked at Dean Moor, which he (Mr. Fletcher) supposed to be the Six-quarter, but about which there was as yet considerable uncertainty. He also noticed that on the diagrams the seam worked at Mealsgate, and called there the Main Band, was shown as being the Yard Band, but so far as he was aware the seam had not been traced in anything like an unbroken line, and the section of the seam, as worked at the Allhallows Colliery, certainly varied very much in many respects from any section of the Yard Band that had come under his notice. Mr. Kendall had also stated that the Udale Band had been proved at Workington, underlying the Main Band at a depth of 77 fathoms, and he (Mr. Martin) would like to know whether that had been proved by boring or sinking?

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Mr. KENDALL replied, that it had been proved by boring.

Mr. MARTIN said as far as he knew, there was no direct boring from the Main Band to the Udale Band at Workington. However, he did not think it would be wise to take up any more time in the discussion until they had Mr. Kendall's paper placed in their hands.

Mr. J. DAGLISH said, that the paper appeared to contain one or two points of very deep interest to those carrying on colliery operations on this coast. With reference to Mr. Kendall's remarks as to the unconformity to the coal-measures, he wished to ask him whether the view he adopted was generally recognised by geologists, or whether his theory was stated now for the first time? He also wished to ask whether any of the large faults were clearly traced through the Permian measures? He might mention that on the East Coast there was some little doubt and difference of opinion as to the exact character of the red rocks immediately overlying the coal-measures; but the generally entertained opinion was that they formed the upper series of the true coal-measures, and that conclusion was borne out by the fact that the fossils found there were coal-measure fossils. Some persons, moreover, hold the view that over the greater part of the Eastern Coal-field the red rocks are simply the reddened edges of the true coal measures, as they approach and under-lie the Permians.

Mr. G. H. LIDDELL drew Mr. Martin's attention to the following extract from the "Archæology of the West Cumberland Coal Trade," by Mr. Isaac Fletcher, page 3:—

The west dip again brings into view, on the coast section, near Barrowmouth, the Whitehaven sandstone before alluded to. This peculiar sandstone was first described many years ago by Professor Sedgwick, who considered it as the local representative of the Permian sandstone, this opinion being chiefly based on the fact that it is unconformable to the coal-measures which it overlays. This proves that it was deposited at a period probably long subsequent to the formation of the regular coal-measures. The more recent researches of geologists seem to establish conclusively that this sandstone cannot be ranked among the Permian rocks, because at two collieries near Maryport two workable seams of coal have been found above this sandstone, and one of them—the Senhouse High Seam—has been worked near Maryport, where it was found upwards of three feet thick. At Mr. Wilson's Pit in Flimby Wood the Senhouse High Seam was found, and underneath it the pit was sunk through seventeen fathoms of Whitehaven sandstone. At Whitehaven these seams have not been found, and its thickness, where it is not diminished by denudation, may be taken to be the same as at Flimby, viz., seventeen fathoms. To illustrate its unconformability to the regular coal-measures, I may mention that at William Pit it is 140 fathoms above the six-quarter seam, whilst at Dean Moor, about six miles distant in a north-east direction, it is only twenty-five

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fathoms above the same seam, and in the intermediate country it is found in varying relations to the underlaying coal seams. It contains many of the coal plants found in the regular measures. It may perhaps be more properly described as a secondary carboniferous formation, intermediate between the main carboniferous series and the Permian rocks reposing upon it.

Mr. MARTIN said he was aware that Mr. Fletcher based his opinion on the theory that the Six-quarter Seam at Whitehaven was the same seam as that worked at Dean Moor; but, with all due respect to Mr. Fletcher, he doubted very much whether the seam at the latter place was the Six-quarter Seam at all. His opinion was that it was not. He was aware that it was the generally received opinion that the sandstone was unconformable to the true coal-measures, but thought the evidence produced so far not altogether satisfactory; and what he should like to know was whether at any point direct unconformity had been proved? that is, where the up-turned edges of the lower measures are overlaid by more horizontal strata of Whitehaven sandstone.

Mr. J. S. DIXON thought it might prove interesting to them to know that in Scotland the upper coal-measures were chiefly sandstones of a red colour, such as referred to by Mr. Martin as being found in the Cumberland coal-field, and also that coal-measure fossils were found in these.

Mr. KENDALL, in replying on the discussion, said with reference to Mr. Martin's remarks as to the unconformity of the Whitehaven sandstone, he might mention that the views he had stated on this point that day were not new, as he had made similar statements about the unconformability of the Whitehaven sandstone five years ago in his paper on "The Hæmatite Deposits of Cumberland," and geologists appeared to be perfectly satisfied on the point. The determination of the unconformity did not rest alone upon the identification of coal seams in different parts of the district, but was also shown, and indeed more clearly, by the fact already pointed out in the paper, that the sandstone in some parts of the district rested directly on the millstone grit, whilst in other areas, as at Croft Pit, it was separated from that formation by the whole thickness of the Lower Coal-measures. The Main Band of Bolton is certainly not the same seam as the Main Band of Workington, Whitehaven, and Cleator Moor, but identical with the Yard Band of Aspatria, Gilcrux, and Cleator Moor. It is called Main Band about Bolton because it is the *main* band, in the sense that it is the most important seam there, whilst *the* Main Band of other parts of the district is so split up in the neigh-

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bourhood of Mealsgate and Bolton that it is of very little value. A great many of the faults found in the coal-field did not pass through the Permians, but stopped at the top of the Coal-measures.

The PRESIDENT, in proposing a hearty vote of thanks to Mr. Kendall for his interesting paper, said he considered the suggestion made by Mr. Martin for the establishment of the Institute in that district and for the occasional holding of meetings was a very good one, and would be worthy of a trial. He also pointed out that the acquaintance of the members with the different districts they made their study would become much more rapid if each of the different seams was called and generally known by one and the same name, instead of by different names.

Mr. DAGLISH seconded the vote of thanks, which was unanimously agreed to.

Mr. LIDDELL then read the following paper "On the Whitehaven Collieries."

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THE WHITEHAVEN COLLIERIES.

By G. H. LIDDELL.

In the following paper the writer proposes to give a brief description of the Earl of Lonsdale's collieries at Whitehaven, so as to enable the members of this Institute to form a general idea of what they are going to see in their forthcoming visit.

Whitehaven collieries occupy the south-western portion of the West Cumberland coal-field, and the coal seams are there found in greater perfection than elsewhere in the same district. The three principal seams are:—the Bannock Band, the Main Band, and the Six-quarter Band, of which the sections and depths at the Wellington Pit, Whitehaven, are as follows:—

	Ft.	Ins.		Fms.
Bannock Band	7	11	at	74
Main Band	10	7	„	96
Six-quarter Band	7	7	„	139

The Main Band is the most important of the three, and, with the exception of about 6 inches of metal and little coal in the middle of the seam, is all of good quality.

The workings at present being carried on, are almost all going westward under the sea, and extend from two to three miles from the shafts.

The general dip of the strata is to the south-west, and being at a steeper gradient than the sea bed, the cover thickens rapidly in that direction.

There are three pits now drawing coals, viz., William Pit, which is on the north side of Whitehaven Harbour, Wellington Pit on the south side, and Croft Pit, which is near the coast, about two miles further south. The last-named pit was sunk in the year 1775, and has worked continuously ever since.

At William Pit the three seams are all being worked, and at Wellington and Croft Pits the Main Band only. As nearly as can be ascertained the coal first began to be worked by Sir Christopher Lowther, an ancestor of the Earl of Lonsdale, about the year 1620.

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A valley runs between Whitehaven and St. Bees which is about five miles south of the former, in which the Bannock and Main Bands crop out, and it is at the outcrop of the former that the first workings appear to have taken place.

The seams are worked in pillars 20 yards square, which are afterwards either split or entirely taken out, according to the thickness of the cover. Under the sea the latter varies from about 50 to 250 fathoms. The usual way of opening out a district is to drive a pair of level ends or headways from the main road, turn away boards to the rise, six yards wide and twenty yards apart, and hole over pointings or walls, off and on, of the same width and distance apart as the boards.

The haggers, or hewers, trail or put their own coals in wooden bogies from the faces of their workings to a platform on the level end, called a stear, from which the coals are shot into iron tubs on the rolleyway, and led by horses to the engine plane.

Until a few years ago the haulage in the Main Band at William Pit was done entirely by horses, of which there were at one time 110 in the pit, the coal being led to the shaft in baskets, in some instances a distance of four miles.

The greater part of this work is now done by compressed air. There are two separate compressing engines on the surface, built by Messrs. Hathorn, Davis, and Davey, and fitted with their differential gear. They are direct-acting, and without cranks. The steam-cylinders are 32 inches in diameter, and the air-cylinders 36 inches in diameter; length of stroke 8 feet. There is a water-jacket on each air-cylinder, in addition to which water is injected inside the cylinders at each stroke, and the air, which is pressed at 30 lbs., is thus kept quite cool.

For several reasons, which will be apparent to those members who inspect the compressors, the writer does not recommend this form of engine for compressing air. The compressed air is conveyed down the pit and in-bye through a range of 8-inch pipes, about 4,000 yards in length. The main engine plane, which is a little over 3,000 yards long, and is driven water-level, is worked by two double 12-inch engines, built by Messrs. Fowler, of Leeds, one being fixed at each end of the plane. This system the writer believes to be much preferable to using a tail-rope, as amongst other things it is of great advantage to have the air-pressure at the in-bye end, ready to be used for any local purpose for which it may be required. The tubs are run in sets of 40, and carry 12 cwts. each.

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Besides the two engines above-named there are two other hauling engines working branch roads, and three small engines pumping water at different parts of the pit. The signalling on the main engine-plane is done by electric bells.

In the Six-quarter at William Pit there is a short engine-plane worked with main and tail-ropes, worked by a small steam hauling engine with multitubular boiler placed at the shaft bottom.

At Wellington and Croft Pits the engine-planes go in the direction of the dip, and are, respectively, one-and-a-half and two miles long. They are each worked with a single rope by a steam hauling engine fixed on the surface, the empty tubs taking the rope in-bye by force of gravity.

At Wellington Pit the engine-plane cannot be extended further in this manner, owing to a rise-fault running north and south.

To overcome this difficulty a hauling engine, which is to be worked by compressed air, is being put down at the in-bye end of the workings, and is intended to work in connection with the steam engine on the surface, similarly to the manner described in William Pit Main Band.

The great bulk of the water met with in the collieries runs out of day-drifts, which are driven from the sea level. A certain quantity, however, finds its way into the workings under the sea, and this is pumped by engines placed at William and Wellington Pits. William Pit pumping engine, which was built in the year 1810, is an atmospheric one, with open-topped cylinder of 80 inches diameter and 8-foot stroke. There are four 12-inch lifting sets in the pit, all at the opposite end of the pumping beam. The steam pressure under the piston is only a few pounds, as the weight of the rods brings up the piston, and the atmospheric pressure does the work of pumping the water.

At Wellington Pit there is a Cornish pumping engine with 90-inch cylinder and 10-foot stroke, which was fitted a few years ago with Davey's differential gear and separate condenser.

The cylinder is placed above the pumping beam, and at the opposite end there are three 20-inch sets of pumps, the two top ones being forcing sets of 57 fathoms each, and the bottom one a lifting set of 25 fathoms. Originally this engine was worked at high pressure, steam being admitted on the top side of the piston only. The steam lifted the forcing-rods and pumped the water in the lifting set, and in the return stroke the weight of the rods pumped the water in the forcing sets. Since the condenser has been applied, the steam, after doing its work on the top side of the piston, has access to the low side and to the condenser during

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the upward stroke, when, of course, the pressure is the same on both sides. During the downward stroke the vacuum comes into play below the piston and so economises the steam-pressure.

The three pits in the Main Band are each ventilated by a 36-foot Guibal fan with duplicate engines, and the Six-quarter is ventilated by a small furnace. It may be interesting here to observe that the system of "coursing the air" was first adopted at these collieries about the beginning of last century by the then manager, Mr. Carlisle Spedding. He also invented the Steel Mill.

Not much fire-damp is met with in ordinary working, but when a new district is tapped, it sometimes gives off a very large quantity for a considerable time.

NATURE OF SEAMS.

The three seams before-mentioned are all of good quality for household and steam purposes. They also make good coke, but the Six-quarter is the best for that purpose.

In former years the small coal was such a drug in the market that it frequently had to be teemed into the sea. Now that its value for coking has been ascertained, Lord Lonsdale is building a range of 73 coke-ovens, of the bee-hive pattern, near William Pit. About 25 of these are now at work, coking the small from all the seams, which is washed in a Sheppard's machine.

In spite of the large quantity of coal which has been worked during the last three centuries, the supply yet available seems practically unlimited. To the seaward the seams appear, if anything, to improve in quality and do not decrease in thickness, and there is a very large area untouched, to the south of the present workings, as is proved by a borehole which was put down near St. Bees, a few years ago, with the diamond borer.

The Bannock Band was there found to be 8 feet thick at a depth of 230 fathoms and the Main Band 7 feet 9 inches thick at 239 fathoms. How far the coal may extend under the New Red Sandstone which here overlies it, it is impossible to tell.

In conclusion, it may be said that the town of Whitehaven, which has a population of about 20,000 inhabitants, owes its existence entirely to the coal trade, and, so far from there being any likelihood of a diminution of that trade, Lord Lonsdale is now building 104 additional colliery cottages near to the town.

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Mr. DAGLISH, in moving a vote of thanks to Mr. Liddell for his paper, which he considered would be of great advantage to those members who were about to visit Lord Lonsdale's collieries, said he had already had the pleasure of seeing the workings which had been described, and he had no doubt that on the occasion of their visit the members would, as he had done, take especial interest in the old atmospheric engine at Whitehaven Colliery, which was erected in 1794, and which, he, believed, was the only one now in use in the country.

Mr. HEDLEY seconded the vote of thanks, which was unanimously passed.

The PRESIDENT then announced that that closed the formal business in connection with their visit to Barrow, the remainder of their stay in the district would be devoted to excursions to the various mines, etc., in the neighbourhood. Before they separated, however, he wished to propose, on behalf of the Institute, a very cordial vote of thanks to the Mayor (Mr. Fell), the Barrow Hæmatite Steel Company, the Barrow Shipbuilding Company, the Barrow Steam Navigation Company, Mr. Wadham, and to the gentlemen connected with the various works and mines they were about to visit, for their great kindness in offering them such facilities as they had done; also, to Sir Jas. Ramsden and Mr. H. Cook for their great kindness in granting them the free use of the Furness railways and in running special trains for their accommodation; and likewise to the reception committee, coupled with the name of Mr. Horace Allen, the Local Secretary.

Mr. JOHN MARLEY seconded the vote of thanks, which was carried amid hearty cheers.

The business of the meeting having concluded, the members were divided into two parties.

The first party was conveyed by special train to Millom, where the following works were visited:—

The Iron Works of the Cumberland Iron Mining and Smelting Company, and

The Mines of the Hodbarrow Mining Company.

Luncheon was provided at Millom by the kindness of the Directors of the Hodbarrow Mining Company and the Cumberland Iron Mining and Smelting Company, jointly.

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On returning the train called at the following places, which were inspected by the party:—

The Mines at Park, belonging to the Barrow Hæmatite Steel Company.

The Mines at Roanhead, belonging to Messrs. Kennedy Brothers, and

The Askam and Mouzell Iron Company's Works, and Iron Ore Mines at Askam.

The second party was conveyed by special train to Stank, where the following places were visited:—

The Stank Mines, belonging to the Barrow Hæmatite Steel Company, and

The Lindal Moor Mines, belonging to Messrs. Harrison, Ainslie, and Company.

Luncheon was provided by the kindness of the Company.

In the evening the members were entertained by the Mayor of Barrow, JOHN FELL, Esq., at a Conversazione in the Town Hall.

THURSDAY, JULY 5TH, 1883.

The members left Barrow for Lakeside, Windermere, by special train.

FRIDAY, JULY, 6TH, 1883.

The members left Barrow by special train for Whitehaven, where another special train was in readiness for those who wished to inspect:—

The Parkside Mining Company's Underground Workings, at Frizington.

This party was received by Mr. George Scoular, and Luncheon was provided for them by the kindness of the Company.

At Whitehaven the party was received by Mr. G. H. Liddell.

The members first went down the "William" pit, then inspected the surface arrangements, and afterwards visited the Lonsdale Iron Works.

Luncheon was kindly provided by the Earl of Lonsdale, at Whitehaven Castle.

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PROCEEDINGS.

ANNUAL GENERAL MEETING, SATURDAY, AUGUST 4TH, 1883, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

JOHN DAGLISH, ESQ., IN THE CHAIR.

MESSRS. S. C. Crone, George May, A. M. Potter, and William Logan, were appointed scrutineers to examine the voting papers for the election of officers for the year 1883–84.

The SECRETARY read the minutes of the General Meeting held on June 9th, and reported the proceedings of the Council.

The annual reports of the Council and Finance Committee were also read.

The following gentlemen were elected, having been previously nominated:—

ORDINARY MEMBERS—

Mr. CHARLES EDWARD RHODES, Mining Engineer, Carr Houses, Rotherham.

Mr. ARTHUR SACKVILLE BOUCHER, La Salada Puerto Bertio, E de Antioquia, U.S. of Columbia, South America.

Mr. C. C. LEACH, at present an Associate Member.

STUDENTS—

Mr. FRANK ROBERT SIMPSON, Hedgefield, Blaydon-on-Tyne.

Mr. EDWARD HEADLY HUTT, Usworth Colliery, *via* Washington Station. R.S.O., County Durham.

The following were nominated for election at the next meeting:—

ORDINARY MEMBERS—

Mr. JAMES GIBSON DEES, Civil Engineer, Floraville, Whitehaven.

Mr. ATHERTON SELBY, Mining Engineer, Leigh, near Manchester.

Mr. ISRAEL KNOWLES, Mining Engineer, Pearson and Knowles Coal and Iron Company, Limited, Wigan.

ASSOCIATE MEMBER—

Mr. WILLIAM FLETCHER, Brigham Hill, *via* Carlisle.

There were no papers to read or discuss, all the available papers having been exhausted at the Meetings in Barrow-in-Furness in July.

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APPENDIX.

BAROMETER AND THERMOMETER READINGS FOR 1882.

BY THE SECRETARY.

THESE readings have been obtained from the observations of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of ·150 of an inch to each reading, and both readings are reduced to 32 degrees Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

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BAROMETER READINGS, &c.

JANUARY, 1882.

KEW.							GLASGOW.						
	BAROMETER.				TEMPERATURE.			BAROMETER.				TEMPERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·819	29·819	29·748	29·855	47·9	36·5	1	29·460	29·376	29·332	29·344	47·0	36·0
2	29·819	29·769	29·669	29·441	50·6	36·6	2	29·066	29·232	29·038	28·687	49·5	39·7
3	29·176	29·267	29·350	29·525	50·9	34·9	3	28·680	28·904	29·193	29·385	47·2	35·4
4	29·686	29·895	29·971	29·967	43·0	33·9	4	29·567	29·708	29·677	29·535	41·1	33·9
5	29·791	29·687	29·681	29·814	52·6	40·0	5	29·234	29·168	29·304	29·498	50·1	40·6
6	29·771	29·657	29·686	29·790	52·8	41·5	6	29·198	28·886	29·058	29·250	49·2	34·9
7	29·791	29·877	30·027	30·202	44·0	39·6	7	29·287	29·438	29·606	29·748	39·8	33·0
8	30·237	30·199	29·965	29·898	49·6	37·8	8	29·768	29·703	29·626	29·704	43·5	36·0
9	29·798	30·100	30·224	30·318	50·5	36·6	9	29·708	29·776	29·853	29·950	43·5	36·8
10	30·321	30·314	30·162	30·119	48·2	34·5	10	29·937	29·815	29·715	29·747	45·1	41·5
11	30·104	30·161	30·189	30·294	51·7	44·4	11	29·859	29·969	30·038	30·097	45·1	39·8
12	30·313	30·400	30·385	30·413	49·1	38·2	12	30·022	30·188	30·302	30·307	49·9	41·9
13	30·391	30·398	30·378	30·427	47·0	40·6	13	30·159	30·135	30·063	30·151	48·0	44·5
14	30·467	30·527	30·551	30·614	43·5	39·1	14	30·177	30·251	30·231	30·274	51·1	43·8
15	30·633	30·682	30·686	30·721	43·1	38·0	15	30·321	30·429	30·459	30·512	51·1	47·8
16	30·749	30·833	30·855	30·868	42·9	37·5	16	30·535	30·633	30·667	30·691	48·0	45·5
17	30·883	30·911	30·889	30·925	37·4	31·1	17	30·708	30·733	30·722	30·764	46·9	44·6
18	30·920	30·942	30·913	30·912	34·2	30·4	18	30·764	30·793	30·810	30·804	47·8	44·7
19	30·890	30·893	30·839	30·808	39·5	32·5	19	30·776	30·778	30·718	30·674	46·8	42·9
20	30·743	30·732	30·684	30·701	40·9	35·3	20	30·591	30·550	30·483	30·446	44·3	40·2
21	30·693	30·727	30·664	30·670	41·3	32·3	21	30·517	30·563	30·515	30·459	44·9	37·8
22	30·622	30·613	30·545	30·543	41·8	30·4	22	30·411	30·375	30·323	30·321	46·4	42·0
23	30·520	30·542	30·549	30·603	37·7	28·0	23	30·284	30·287	30·295	30·336	47·8	43·2
24	30·636	30·709	30·691	30·727	41·9	25·6	24	30·374	30·452	30·467	30·481	47·7	45·6
25	30·708	30·729	30·667	30·639	34·5	23·4	25	30·493	30·516	30·514	30·526	46·1	40·6
26	30·585	30·561	30·480	30·430	35·8	31·0	26	30·456	30·374	30·251	30·184	41·2	39·2
27	30·377	30·372	30·336	30·352	46·8	35·7	27	30·116	30·076	29·958	29·810	48·7	39·8
28	30·302	30·281	30·256	30·249	50·8	43·9	28	29·718	29·974	30·035	30·137	47·7	34·1
29	30·223	30·169	30·032	30·051	48·6	41·4	29	30·209	30·289	30·302	30·304	38·5	31·0
30	30·146	30·279	30·353	30·458	43·6	39·2	30	30·427	30·464	30·453	30·491	39·3	34·8
31	30·531	30·630	30·638	30·677	41·9	38·8	31	30·476	30·518	30·504	30·524	42·3	37·0

FEBRUARY, 1882.

1	30·664	30·663	30·566	30·535	39·5	28·5	1	30·519	30·516	30·428	30·343	42·0	38·7
2	30·486	30·524	30·520	30·573	38·4	23·2	2	30·239	30·267	30·338	30·422	47·1	38·9
3	30·552	30·590	30·540	30·528	42·6	28·9	3	30·369	30·350	30·324	30·267	45·8	39·8
4	30·485	30·493	30·433	30·435	40·2	27·5	4	30·353	30·278	30·276	30·311	47·9	41·9
5	30·413	30·431	30·410	30·436	37·3	30·0	5	30·311	30·322	30·328	30·377	45·6	41·0
6	30·440	30·497	30·486	30·520	43·4	33·5	6	30·393	30·440	30·454	30·494	45·0	38·1
7	30·521	30·532	30·479	30·483	44·8	38·9	7	30·488	30·495	30·435	30·425	44·2	37·2
8	30·443	30·429	30·385	30·396	42·6	35·3	8	30·372	30·328	30·250	30·208	45·0	38·9
9	30·396	30·405	30·362	30·335	38·1	34·4	9	30·153	30·100	29·969	29·906	48·0	39·0
10	30·263	30·236	30·144	30·096	45·4	33·4	10	29·826	29·792	29·791	29·769	48·1	45·3
11	29·992	29·935	29·817	29·796	50·3	32·9	11	29·704	29·662	29·575	29·519	48·3	44·0
12	29·811	29·931	30·017	30·092	53·8	40·9	12	29·547	29·693	29·705	29·532	46·8	43·2
13	—	30·008	29·965	30·048	51·7	42·1	13	29·279	29·239	29·402	29·600	50·8	41·5
14	30·081	30·186	30·224	30·119	54·6	48·1	14	29·658	29·791	29·963	29·987	48·2	35·6
15	29·898	29·805	29·959	30·248	51·5	35·6	15	29·666	29·735	29·916	30·111	41·4	32·9
16	30·392	30·390	30·228	30·211	50·0	32·4	16	30·044	29·853	29·830	29·862	48·0	33·8
17	30·198	30·228	30·257	30·324	51·7	45·3	17	29·868	29·929	29·950	29·946	48·9	41·9
18	30·275	30·239	30·114	30·247	52·0	40·7	18	29·776	29·673	29·853	30·164	49·2	37·9
19	30·400	30·584	30·658	30·762	48·5	37·1	19	30·334	30·489	30·570	30·629	48·3	37·0
20	30·776	30·812	30·704	30·655	47·6	33·0	20	30·547	30·514	30·443	30·488	49·2	42·6
21	30·577	30·593	30·619	30·682	51·7	42·5	21	30·488	30·591	30·592	30·601	53·7	46·3
22	30·670	30·630	30·501	30·458	52·9	42·9	22	30·524	30·436	30·440	30·289	48·2	44·1
23	30·418	30·404	30·325	30·271	45·7	41·5	23	30·229	30·200	30·136	30·101	48·1	43·2
24	30·180	30·145	30·121	30·098	48·0	40·9	24	30·015	29·953	29·858	29·785	46·0	41·5
25	29·956	29·800	29·604	29·453	54·3	44·6	25	29·572	29·294	29·014	28·936	51·0	42·9
26	29·324	29·109	29·022	29·062	55·1	48·0	26	28·852	28·800	28·782	28·896	51·6	40·2
27	29·059	29·116	29·196	29·361	52·6	42·8	27	28·999	29·169	29·317	29·465	41·7	35·0
28	29·539	29·561	29·374	28·979	50·0	41·4	28	29·502	29·468	29·390	29·154	38·8	32·7

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BAROMETER READINGS, &c.

MARCH, 1882.

	KEW.						GLASGOW.					
	Barometer.				Temperature.		Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	28·770	28·975	29·026	29·117	50·8	42·9	28·967	28·901	28·896	28·911	40·0	36·0
2	29·217	29·308	29·334	29·346	49·4	38·7	28·857	28·987	29·042	29·123	44·0	36·5
3	29·345	29·395	29·412	29·503	46·7	33·9	29·247	29·418	29·486	29·531	45·0	40·2
4	29·566	29·653	29·633	29·713	48·5	30·7	29·445	29·342	29·324	29·400	49·1	37·0
5	29·748	29·751	29·651	29·558	51·7	40·2	29·384	29·236	30·088	30·088	48·1	39·2
6	29·595	29·817	29·991	30·192	49·7	35·1	29·279	29·606	29·880	29·990	40·7	35·0
7	30·223	30·205	30·175	30·215	54·0	35·5	29·828	29·682	29·707	29·695	53·0	32·0
8	30·211	30·243	30·215	30·308	55·7	47·9	29·678	29·684	29·872	30·024	51·5	40·7
9	30·312	30·322	30·284	30·292	54·4	49·5	29·931	29·786	29·772	29·861	52·1	40·1
10	30·249	30·304	30·304	30·340	54·4	49·8	29·759	29·861	29·866	30·079	52·2	40·0
11	30·375	30·436	30·390	30·427	56·7	45·5	30·175	30·225	30·225	30·260	48·0	39·3
12	30·439	30·498	30·477	30·523	54·1	38·6	30·280	30·289	30·262	30·255	49·1	40·9
13	30·532	30·564	30·505	30·514	55·0	34·0	30·259	30·326	30·307	30·311	51·0	44·8
14	30·469	30·439	30·330	30·346	57·4	32·3	30·239	30·195	30·116	30·110	50·7	44·5
15	30·383	30·514	30·541	30·612	57·6	35·4	30·272	30·417	30·382	30·397	50·1	39·0
16	30·599	30·616	30·550	30·565	60·5	32·0	30·364	30·355	30·398	30·432	53·3	41·2
17	30·542	30·552	30·459	30·434	60·1	32·6	30·416	30·435	30·386	30·306	49·0	42·2
18	30·389	30·320	30·198	30·176	61·5	31·4	30·299	30·113	30·006	29·921	51·0	41·3
19	30·117	30·067	29·930	29·886	58·0	35·7	29·855	29·765	29·569	29·469	50·1	45·8
20	29·818	29·781	29·727	29·776	61·0	39·7	29·487	29·502	29·494	29·381	47·5	36·6
21	29·740	29·726	29·686	29·695	48·6	34·1	29·327	29·426	29·558	29·620	39·2	30·7
22	29·789	29·955	30·115	30·235	44·1	31·7	29·899	30·175	30·212	30·179	43·1	32·7
23	30·243	30·223	30·072	29·998	49·0	30·6	29·982	29·832	29·764	29·655	50·1	37·9
24	29·877	29·773	29·601	29·611	55·0	45·5	29·436	29·182	29·264	29·353	47·6	37·9
25	29·709	29·749	29·660	29·451	53·8	38·7	29·377	29·385	29·350	29·247	46·1	33·2
26	29·016	29·386	29·669	29·911	50·4	35·5	29·275	29·441	29·666	29·839	45·7	35·2
27	30·036	30·117	30·104	30·160	51·4	38·9	29·796	29·782	29·828	29·890	50·1	41·0
28	30·180	30·180	30·125	30·100	53·7	40·4	29·837	29·784	29·739	29·748	53·5	44·8
29	30·027	29·972	29·841	29·797	56·7	46·0	29·656	29·555	29·433	29·431	53·5	38·7
30	29·711	29·651	29·547	29·524	54·9	43·0	29·452	29·424	29·488	29·531	50·0	37·3
31	29·494	29·545	29·571	29·651	53·3	38·7	29·506	29·524	29·527	29·611	45·3	34·4

APRIL, 1882.

1	29·661	29·741	29·758	29·817	59·0	41·3	29·680	29·802	29·907	29·998	46·8	37·8
2	29·778	29·819	29·849	29·911	56·0	44·8	30·024	30·046	30·030	30·048	46·0	40·8
3	29·891	29·905	29·895	29·953	54·6	46·4	30·047	30·036	30·009	30·046	43·1	40·3
4	29·965	30·037	30·035	30·077	53·7	42·2	30·061	30·117	30·136	30·241	53·9	40·4
5	30·045	30·041	30·040	30·127	51·5	40·1	30·255	30·306	30·246	30·271	45·2	38·0
6	30·138	30·194	30·196	30·254	50·5	37·6	30·284	30·342	30·367	30·430	49·3	41·6
7	30·250	30·279	30·252	30·301	56·4	39·0	30·446	30·492	30·456	30·521	53·0	38·9
8	30·313	30·317	30·283	30·287	58·4	40·3	30·515	30·496	30·425	30·417	56·3	36·0
9	30·270	30·247	30·167	30·180	55·6	35·6	30·369	30·321	30·219	30·182	54·2	36·1
10	30·132	30·114	30·034	29·993	53·7	36·5	30·112	30·047	29·980	29·969	49·0	31·3
11	29·914	29·906	29·818	29·818	57·9	35·8	29·922	29·872	29·804	29·799	48·0	37·1
12	29·792	29·768	29·709	29·647	57·1	35·5	29·747	29·726	29·680	29·608	50·0	35·2
13	29·508	29·375	29·175	28·998	52·7	47·2	29·476	29·358	29·197	29·113	42·4	39·6
14	29·167	29·258	29·267	29·310	57·5	44·8	29·053	29·083	29·164	29·317	42·7	37·0
15	29·302	29·376	29·425	29·626	54·9	39·5	29·416	29·547	29·608	29·668	45·0	29·9
16	29·704	29·777	29·714	29·660	53·4	33·6	29·614	29·552	29·480	29·444	47·3	29·9
17	29·523	29·407	29·317	29·355	56·7	43·8	29·314	29·230	29·182	29·229	54·2	42·1
18	29·491	29·720	29·907	30·023	54·5	43·1	29·463	29·714	29·816	29·808	52·2	40·4
19	30·027	29·997	29·995	29·975	56·5	44·4	29·651	29·542	29·539	29·557	54·7	43·1
20	29·860	30·015	30·132	30·254	62·7	45·5	29·577	29·765	29·877	29·936	57·9	47·0
21	30·253	30·255	30·101	29·968	62·7	36·0	29·934	29·939	29·912	29·890	54·9	47·5
22	29·749	29·644	29·540	29·508	59·6	49·0	29·741	29·574	29·394	29·341	54·2	45·7
23	29·320	29·222	29·320	29·403	59·6	48·4	29·255	29·188	29·138	29·176	55·1	41·8
24	29·402	29·469	29·503	29·498	57·5	43·7	29·192	29·120	29·187	29·303	50·4	41·2
25	29·495	29·438	29·115	29·151	52·6	38·8	29·297	29·267	29·201	29·258	52·0	37·5
26	29·258	29·340	29·448	29·599	52·3	39·1	29·308	29·419	29·520	29·623	48·2	37·4
27	29·678	29·748	29·723	29·645	52·0	37·8	29·645	29·621	29·491	29·292	50·0	32·0
28	29·360	29·195	29·226	29·434	54·5	41·0	29·115	29·090	29·133	29·192	47·0	42·5
29	29·529	29·416	28·982	29·297	53·9	39·7	29·256	29·247	29·133	29·233	51·2	37·0
30	29·635	29·760	29·726	29·705	54·8	38·3	29·351	29·443	29·433	29·439	51·6	38·0

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BAROMETER READINGS, &c.

MAY, 1882.

	KEW.						GLASGOW.					
	Barometer.				Temperature.		Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·648	29·699	29·749	29·820	57·7	42·0	29·423	29·380	29·356	29·420	54·3	37·8
2	29·850	29·895	29·904	29·913	60·6	43·5	29·482	29·534	29·629	29·786	54·4	41·0
3	29·822	29·765	29·656	29·686	69·3	47·5	29·814	29·794	29·665	29·614	55·0	38·4
4	29·607	29·642	29·672	29·732	61·4	47·6	29·587	29·626	29·619	29·702	57·0	45·4
5	29·780	29·848	29·839	29·866	64·4	45·5	29·736	29·770	29·772	29·903	55·5	41·5
6	29·816	29·867	29·877	29·925	62·7	49·2	29·767	29·785	29·790	29·846	56·3	40·9
7	29·929	29·946	29·889	29·921	65·1	43·9	29·864	29·912	29·938	29·999	48·5	42·7
8	29·937	29·998	30·073	30·255	56·7	43·0	30·045	30·131	30·177	30·233	49·9	39·9
9	30·337	30·401	30·371	30·355	57·8	41·1	30·193	30·135	30·034	30·124	51·1	41·4
10	30·310	30·339	30·390	30·340	66·6	50·3	30·214	30·253	30·241	30·210	58·1	38·3
11	30·313	30·287	30·167	30·137	68·5	47·3	30·159	30·073	29·859	29·947	53·4	44·0
12	30·138	30·222	30·225	30·291	62·9	45·8	30·051	30·140	30·213	30·262	55·4	41·1
13	30·301	30·323	30·270	30·317	64·0	39·9	30·286	30·331	30·298	30·332	60·1	39·6
14	30·294	30·301	30·235	30·263	56·6	40·5	30·352	30·367	30·353	30·389	56·3	41·6
15	30·219	30·224	30·208	30·290	52·0	39·7	30·357	30·365	30·339	30·399	54·3	37·6
16	30·322	30·362	30·357	30·422	57·1	38·5	30·406	30·427	30·396	30·424	62·8	40·0
17	——	30·453	30·398	30·400	59·0	37·0	30·427	30·415	30·377	30·380	67·4	39·9
18	30·388	30·376	30·274	30·256	63·7	39·9	30·358	30·346	30·259	30·249	69·9	43·3
19	30·207	30·152	30·036	29·980	61·9	41·4	30·212	30·174	30·061	30·136	67·4	46·0
20	29·879	29·848	29·814	29·825	60·6	46·3	30·111	30·070	30·007	30·046	58·4	44·8
21	29·788	29·844	29·856	29·916	67·1	48·5	29·973	29·950	29·921	29·962	60·4	43·7
22	29·873	29·810	29·726	29·696	71·9	46·7	29·953	29·917	29·776	29·751	63·8	45·7
23	29·612	29·548	29·495	29·504	70·5	53·6	29·677	29·602	29·451	29·368	65·2	44·0
24	29·437	29·438	29·449	29·504	64·0	51·0	29·359	29·136	29·043	29·103	57·8	47·2
25	29·466	29·322	29·411	29·582	59·6	50·5	29·210	29·303	29·310	29·383	63·2	44·9
26	29·669	29·762	29·821	29·915	64·7	52·8	29·389	29·513	29·539	29·602	64·0	49·5
27	29·933	29·994	30·042	30·113	67·1	52·2	29·574	29·632	29·678	29·770	61·0	49·9
28	30·139	30·149	30·133	30·188	69·5	49·3	29·819	29·879	29·934	30·016	62·9	49·2
29	30·231	30·293	30·266	30·293	69·8	48·4	30·068	30·171	30·188	30·257	62·8	47·3
30	30·269	30·253	30·192	30·251	67·6	51·8	30·271	30·316	30·284	30·297	64·1	45·0
31	30·240	30·254	30·241	30·285	65·0	47·4	30·280	30·290	30·267	30·315	66·9	43·9

JUNE, 1882.

1	30·294	30·288	30·225	30·206	60·9	45·3	1	30·337	30·315	30·244	30·233	68·1	47·5
2	30·121	30·105	30·023	29·951	60·4	50·9	2	30·221	30·163	30·038	30·026	66·0	48·7
3	29·869	29·788	29·652	29·712	68·0	52·6	3	29·928	29·836	29·700	29·604	59·4	50·0
4	29·711	29·690	29·635	29·731	67·2	52·2	4	29·460	29·423	29·388	29·403	63·2	51·2
5	29·760	29·768	29·786	29·792	62·9	50·0	5	29·396	29·400	29·369	29·382	64·0	48·1
6	29·663	29·684	29·690	29·677	68·4	54·4	6	29·362	29·349	29·339	29·377	64·7	51·0
7	29·675	29·720	29·749	29·821	65·8	51·9	7	29·392	29·462	29·584	29·649	60·6	50·7
8	29·847	29·842	29·724	29·551	63·1	49·3	8	29·635	29·596	29·469	29·314	57·2	48·4
9	29·439	29·414	29·414	29·436	60·0	49·5	9	29·179	29·244	29·364	29·510	58·4	49·3
10	29·429	29·563	29·720	29·842	59·1	51·4	10	29·622	29·747	29·944	29·917	59·2	46·0
11	29·925	29·992	29·980	29·936	59·5	49·4	11	29·924	29·873	29·715	29·747	55·7	41·3
12	29·809	29·786	29·786	29·842	57·2	44·2	12	29·747	29·875	29·770	29·818	52·0	40·1
13	29·891	29·962	29·926	29·788	55·7	43·0	13	29·808	29·763	29·598	29·609	52·0	41·6
14	29·761	29·813	29·768	29·760	62·1	52·2	14	29·512	29·362	29·368	29·315	56·6	48·4
15	29·745	29·863	29·959	30·077	62·6	46·2	15	29·617	29·821	29·938	30·059	58·8	44·9
16	30·117	30·183	30·171	30·167	64·0	41·4	16	30·105	30·143	30·113	30·070	60·7	39·6
17	30·150	30·097	29·992	29·899	65·2	41·3	17	29·972	29·846	29·739	29·615	54·2	44·4
18	29·778	29·674	29·582	29·619	62·1	49·3	18	29·470	29·466	29·491	29·570	57·1	49·2
19	29·660	29·748	29·807	29·867	64·1	49·0	19	29·627	29·688	29·701	29·739	62·0	50·1
20	29·860	29·869	29·881	29·913	67·1	49·5	20	29·741	29·743	29·718	29·674	62·9	45·7
21	29·895	29·879	29·852	29·846	64·6	50·1	21	29·509	29·545	29·654	29·714	60·1	50·7
22	29·796	29·757	29·696	29·699	62·5	56·0	22	29·696	29·680	29·636	29·611	61·1	48·0
23	29·786	29·851	29·888	29·939	65·2	46·9	23	29·622	29·642	29·700	29·792	63·7	47·2
24	29·933	29·946	29·916	29·900	69·1	48·4	24	29·826	29·853	29·834	29·882	67·0	52·3
25	29·896	29·974	30·003	30·044	69·4	51·4	25	29·786	29·834	29·905	29·973	65·4	50·8
26	30·017	29·966	29·925	29·978	68·9	48·9	26	29·977	29·946	29·978	30·010	63·2	45·8
27	30·037	30·066	30·060	30·114	72·2	50·2	27	30·026	30·032	30·036	30·056	66·9	45·3
28	30·128	30·159	30·143	30·159	70·8	54·8	28	30·054	30·056	30·048	30·091	68·2	52·4
29	30·139	30·123	30·062	30·062	67·5	57·5	29	30·066	30·099	30·083	30·110	70·4	52·4
30	30·065	30·092	30·084	30·090	64·5	48·7	30	30·114	30·110	30·066	30·091	73·2	51·8

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BAROMETER READINGS, &c.

JULY, 1882.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·081	30·078	30·040	30·057	71·5	42·8	1	30·076	30·035	29·969	29·991	72·4	50·8
2	30·052	30·063	30·064	30·099	72·1	54·2	2	29·995	29·996	30·000	30·009	69·4	53·0
3	30·075	30·074	30·005	29·967	75·5	55·0	3	29·932	29·863	29·779	29·677	61·7	55·7
4	29·865	29·800	29·710	29·623	66·0	56·2	4	29·555	29·490	29·424	29·407	63·0	55·6
5	29·490	29·496	29·477	29·522	66·2	54·7	5	29·326	29·275	29·205	29·214	65·0	51·0
6	29·508	29·470	29·317	29·335	62·8	54·1	6	29·180	29·151	29·095	29·077	63·3	50·3
7	29·323	29·546	29·361	29·395	66·9	53·0	7	29·055	29·078	29·109	29·170	62·9	50·3
8	29·437	29·464	29·477	29·544	64·8	51·3	8	29·201	29·253	29·295	29·355	65·9	49·9
9	29·549	29·580	29·607	29·684	66·2	52·2	9	29·360	29·359	29·435	29·481	62·3	49·5
10	29·692	29·712	29·728	29·745	66·2	49·9	10	29·489	29·518	29·534	29·564	66·0	52·0
11	29·687	29·550	29·385	29·369	66·0	51·8	11	29·548	29·526	29·510	29·576	64·5	52·3
12	29·512	29·767	29·876	29·951	70·1	53·6	12	29·637	29·721	29·751	29·767	67·3	52·7
13	29·924	29·872	29·753	29·664	67·1	55·6	13	29·682	29·538	29·415	29·312	62·8	53·4
14	29·587	29·625	29·622	29·580	70·8	58·4	14	29·298	29·361	29·388	29·344	67·3	55·3
15	29·482	29·448	29·437	29·518	70·9	55·4	15	29·181	29·148	29·133	29·249	68·0	56·0
16	29·538	29·578	29·619	29·717	70·7	53·9	16	29·238	29·236	29·342	29·470	65·0	54·7
17	29·763	29·816	29·823	29·779	67·8	55·2	17	29·547	29·584	29·562	29·480	64·7	52·6
18	29·764	29·877	29·893	29·905	68·5	57·6	18	29·489	29·549	29·538	29·498	63·6	50·1
19	29·962	30·043	30·045	30·070	68·8	54·1	19	29·506	29·634	29·705	29·776	63·9	50·9
20	30·117	30·164	30·115	30·122	70·8	50·7	20	29·777	29·838	29·886	29·908	62·1	51·0
21	30·047	30·000	29·927	29·869	69·9	49·3	21	29·825	29·713	29·664	29·652	63·0	51·9
22	29·809	29·813	29·740	29·744	69·5	57·6	22	29·569	29·572	29·528	29·507	61·9	53·0
23	29·699	29·571	29·589	29·663	68·3	53·7	23	29·432	29·368	29·303	29·293	62·5	51·8
24	29·674	29·726	29·778	29·842	67·1	53·0	24	29·325	29·437	29·528	29·637	63·6	49·7
25	29·827	29·839	29·830	29·935	64·1	52·8	25	29·693	29·776	*	30·048	64·1	47·6
26	30·062	30·242	30·325	30·415	66·8	51·8	26	*	30·251	30·289	30·322	65·3	46·6
27	30·432	30·433	30·371	30·358	71·8	50·7	27	30·287	30·229	30·168	30·150	58·0	50·6
28	30·333	30·310	30·277	30·268	67·6	56·1	28	30·195	30·245	30·246	30·242	64·0	53·9
29	30·217	30·201	30·124	30·114	72·5	53·6	29	30·173	30·134	30·081	30·018	66·0	53·2
30	30·074	30·072	30·028	30·128	74·6	54·8	30	29·960	30·003	30·048	30·131	62·5	50·3
31	30·207	30·276	30·253	30·246	69·9	50·8	31	30·138	30·150	30·075	29·993	58·2	50·7

* Readings lost.

AUGUST, 1882.

1	30·180	30·163	30·127	30·137	73·8	59·6	1	29·961	29·953	29·962	29·927	63·0	57·0
2	30·095	30·039	30·004	30·023	76·2	56·0	2	29·769	29·696	29·843	29·949	60·8	52·1
3	30·053	30·153	30·197	30·235	65·7	50·9	3	29·976	30·073	30·139	30·205	60·0	50·1
4	30·241	30·263	30·238	30·255	67·5	50·3	4	30·202	30·209	30·211	30·203	63·0	47·0
5	30·224	30·208	30·193	30·208	69·8	51·8	5	30·184	30·182	30·175	30·175	65·7	54·6
6	30·171	30·145	30·075	30·106	78·5	51·7	6	30·099	30·076	30·059	30·091	64·9	52·8
7	30·107	30·137	30·136	30·157	69·5	57·3	7	30·096	30·137	30·141	30·156	66·2	51·5
8	30·164	30·174	30·132	30·157	68·4	52·8	8	30·161	30·177	30·141	30·153	68·7	47·2
9	30·171	30·209	30·164	30·188	70·6	47·5	9	30·152	30·189	30·185	30·210	71·9	47·7
10	30·216	30·237	30·223	30·227	62·2	54·7	10	30·199	30·192	30·151	30·145	74·0	50·0
11	30·195	30·181	30·094	30·067	69·0	55·2	11	30·100	30·066	30·005	29·949	74·1	54·0
12	29·998	29·951	29·862	29·876	79·8	50·8	12	29·876	29·855	29·831	29·798	66·8	53·0
13	29·724	29·785	29·792	29·832	69·7	59·8	13	29·742	29·750	29·578	29·580	65·0	50·4
14	29·828	29·839	29·818	29·807	73·0	55·6	14	29·542	29·595	29·586	29·579	69·3	59·0
15	29·756	29·676	29·659	29·690	69·7	52·0	15	29·479	29·434	29·454	29·343	61·7	55·1
16	29·512	29·604	29·638	29·721	65·8	50·8	16	29·488	29·594	29·620	29·678	70·7	55·2
17	29·740	29·802	29·844	29·895	66·6	53·4	17	29·684	29·718	29·704	29·717	67·1	55·3
18	29·902	29·948	29·952	29·965	70·9	52·6	18	29·778	29·858	29·874	29·886	64·2	53·0
19	29·911	29·902	29·926	29·934	68·3	55·7	19	29·841	29·829	29·821	29·847	65·0	52·8
20	29·995	29·995	29·906	29·801	69·8	48·7	20	29·815	29·710	29·527	29·474	59·8	49·1
21	29·700	29·739	29·711	29·760	64·9	53·7	21	29·433	29·392	29·388	29·442	56·9	53·0
22	29·780	29·809	29·731	29·468	64·6	51·8	22	29·522	29·557	29·468	29·275	57·3	50·4
23	29·262	29·303	29·422	29·501	64·3	52·0	23	29·075	29·122	29·169	29·236	59·9	48·7
24	29·510	29·583	29·576	29·616	61·6	48·5	24	29·227	29·279	29·329	29·384	62·4	47·2
25	29·582	29·464	29·302	29·337	65·8	52·5	25	29·341	29·352	29·342	29·398	62·8	48·9
26	29·395	29·543	29·614	29·711	66·5	53·0	26	29·415	29·479	29·526	29·585	63·2	48·8
27	29·729	29·758	29·740	29·763	65·0	52·6	27	29·592	29·629	29·625	29·661	64·0	52·0
28	29·746	29·738	29·645	29·572	64·9	48·1	28	29·599	29·499	29·316	29·299	56·4	49·8
29	29·493	29·391	29·546	29·747	62·9	52·7	29	29·288	29·331	29·502	29·656	61·5	47·9
30	29·815	29·929	29·973	30·068	66·7	50·0	30	29·739	29·864	29·935	29·990	61·0	45·8
31	30·065	30·086	29·934	29·850	62·5	45·0	31	29·970	29·925	29·805	29·710	60·6	45·1

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BAROMETER READINGS, &c.

SEPTEMBER, 1882.

	KEW.						GLASGOW.					
	Barometer.				Temperature.		Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·754	29·718	29·630	29·548	65·4	56·0	29·545	29·429	29·188	29·171	61·8	51·9
2	29·493	29·495	29·514	29·604	67·5	57·9	29·024	29·031	29·153	29·234	63·0	54·2
3	29·688	29·745	29·771	29·875	68·0	56·4	29·354	29·537	29·700	29·873	63·4	52·8
4	29·979	30·109	30·147	30·197	66·6	53·2	29·981	30·065	30·056	29·985	59·4	44·8
5	30·176	30·192	30·126	30·105	61·9	52·6	29·859	29·931	30·003	30·068	61·0	48·1
6	——	30·207	30·214	30·302	62·6	51·8	30·035	30·142	30·283	30·343	60·3	45·3
7	30·324	30·354	30·304	30·323	65·1	47·1	30·345	30·347	30·284	30·254	59·2	42·3
8	30·321	30·315	30·317	30·359	64·6	42·9	30·250	30·314	30·340	30·390	62·0	45·1
9	30·340	30·316	30·211	30·158	64·8	42·7	30·345	30·286	30·149	30·074	60·4	40·6
10	30·020	29·944	29·807	29·776	66·2	47·9	29·918	29·802	29·686	29·626	57·3	45·8
11	29·711	29·690	29·629	29·625	64·5	43·0	29·564	29·562	29·553	29·582	55·3	42·3
12	29·590	29·596	29·579	29·633	59·5	47·0	29·578	29·588	29·569	29·596	56·3	35·9
13	29·635	29·664	29·634	29·626	59·5	40·5	29·588	29·619	29·600	29·606	56·2	41·0
14	29·587	29·585	29·571	29·605	57·8	39·9	29·552	29·520	29·476	29·521	56·8	42·2
15	29·632	29·716	29·763	29·826	61·7	36·5	29·563	29·635	29·653	29·706	57·6	51·3
16	29·830	29·885	29·878	29·930	63·5	37·0	29·685	29·759	29·807	29·872	56·8	48·0
17	29·931	29·971	29·949	29·983	63·8	42·7	29·853	29·879	29·893	29·920	57·0	43·2
18	29·981	29·990	29·966	29·979	60·7	47·9	29·926	30·002	30·028	30·096	57·3	40·1
19	29·959	29·927	29·759	29·711	58·0	44·6	30·115	30·115	30·051	30·084	59·8	41·0
20	29·644	29·662	29·713	29·791	60·5	48·9	30·068	30·050	30·000	30·040	56·7	46·9
21	29·781	29·770	29·770	29·806	61·3	48·0	30·015	30·022	29·976	29·968	54·3	47·3
22	29·810	29·861	29·873	29·948	61·9	46·7	29·922	29·912	29·873	29·868	55·7	49·4
23	29·965	29·993	29·971	30·005	61·0	39·8	29·845	29·851	29·833	29·810	54·0	50·9
24	29·993	30·012	29·944	29·925	62·5	48·8	29·733	29·758	29·758	29·738	55·8	51·4
25	29·853	29·822	29·715	29·653	66·1	49·9	29·674	29·601	29·622	29·626	56·4	49·6
26	29·516	29·439	29·373	29·309	60·8	49·8	29·539	29·492	29·398	29·332	59·4	50·0
27	29·206	29·202	29·315	29·476	57·7	46·8	29·210	29·181	29·188	29·225	54·0	50·0
28	29·583	29·669	29·668	29·611	60·5	43·7	29·307	29·418	29·496	29·501	55·2	45·1
29	29·359	29·318	29·607	29·746	56·7	47·8	29·455	29·477	29·532	29·634	53·9	40·8
30	29·836	29·904	29·840	29·840	61·2	45·2	29·687	29·716	29·548	29·458	57·2	39·0

OCTOBER, 1882.

1	29·859	29·848	29·739	29·801	68·6	55·9	1	29·456	29·392	29·230	29·421	66·1	51·3
2	29·920	30·031	30·034	30·037	64·1	49·6	2	29·578	29·653	29·632	29·598	58·1	48·0
3	30·050	30·186	30·248	30·352	61·0	45·0	3	29·719	29·926	30·101	30·208	55·8	49·0
4	30·395	30·439	30·426	30·496	57·9	44·7	4	30·292	30·428	30·499	30·575	58·0	49·7
5	30·461	30·424	30·303	30·234	59·1	46·8	5	30·581	30·611	30·560	30·544	57·3	44·1
6	30·150	30·140	30·084	30·057	58·2	52·1	6	30·479	30·474	30·385	30·363	56·9	49·5
7	30·002	30·052	30·028	30·060	63·4	47·4	7	30·361	30·224	30·157	30·123	54·8	50·8
8	30·052	30·078	30·052	30·093	62·5	43·6	8	30·071	30·111	30·084	30·081	57·2	53·0
9	30·098	30·130	30·097	30·103	63·6	46·4	9	30·045	30·047	30·039	30·050	54·8	45·9
10	30·064	30·042	29·940	29·884	61·0	47·2	10	30·027	30·010	29·875	29·746	53·3	46·0
11	29·779	29·653	29·520	29·467	60·1	51·8	11	29·594	29·490	29·311	29·376	57·9	48·4
12	29·457	29·488	29·509	29·599	56·7	47·6	12	29·439	29·540	29·617	29·738	58·7	47·3
13	29·653	29·739	29·789	29·854	59·9	45·5	13	29·796	29·872	29·928	29·972	57·5	54·2
14	29·879	29·936	29·958	29·986	56·8	48·8	14	29·954	29·971	29·943	29·901	55·2	52·1
15	29·956	29·946	29·873	29·834	55·0	45·2	15	29·837	29·801	29·767	29·734	53·1	49·8
16	29·724	29·637	29·551	29·551	49·1	45·7	16	29·719	29·774	29·778	29·824	50·2	45·0
17	29·605	29·741	29·878	29·998	49·8	43·6	17	29·854	29·931	29·971	30·047	51·5	41·8
18	30·055	30·126	30·084	30·050	55·3	41·5	18	30·084	30·092	30·009	29·913	53·3	39·9
19	29·939	29·864	29·736	29·694	55·4	48·8	19	29·743	29·634	29·531	29·537	53·7	46·0
20	29·707	29·804	29·794	29·800	59·1	44·9	20	29·526	29·541	29·516	29·536	54·4	44·0
21	29·702	29·490	29·423	29·350	57·4	47·8	21	29·477	29·394	29·231	29·171	51·4	43·2
22	29·174	29·211	29·355	29·434	55·0	42·3	22	29·107	29·060	29·073	29·112	49·5	40·9
23	29·435	29·493	29·512	29·549	54·0	41·1	23	29·108	29·131	29·136	29·215	49·8	41·0
24	29·470	28·910	29·255	29·458	55·6	39·5	24	29·252	29·237	29·216	29·265	47·6	37·8
25	29·497	29·546	29·532	29·553	51·3	33·6	25	29·322	29·375	29·416	29·451	50·2	35·8
26	29·535	29·546	29·480	29·395	51·6	29·9	26	29·429	29·441	29·426	29·465	48·7	39·1
27	29·373	29·377	29·343	29·379	50·8	40·8	27	29·530	29·621	29·685	29·779	49·0	32·8
28	29·369	29·425	29·504	29·586	49·7	46·6	28	29·841	29·905	29·915	29·939	49·3	36·9
29	29·639	29·741	29·840	29·919	49·9	38·5	29	29·889	29·881	29·815	29·723	44·8	32·1
30	29·914	29·842	29·752	29·730	52·9	34·6	30	29·565	29·501	29·491	29·562	44·6	36·9
31	29·894	30·022	29·997	29·939	55·5	40·6	31	29·648	29·772	29·771	29·711	50·4	42·7

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BAROMETER READINGS, &c.

NOVEMBER, 1882.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·799	29·614	29·427	29·587	57·5	49·3	1	29·524	29·371	29·172	29·210	53·0	44·9
2	29·768	29·822	29·725	29·738	56·7	46·8	2	29·367	29·350	29·320	29·298	51·6	45·3
3	29·721	29·851	29·812	29·668	56·0	50·8	3	29·392	29·468	29·108	29·057	51·8	43·2
4	29·570	29·644	29·752	29·930	56·9	48·1	4	28·988	29·083	29·279	29·478	50·0	44·1
5	29·979	29·916	29·814	29·862	59·8	47·5	5	29·534	29·322	29·201	29·618	54·7	41·9
6	30·012	30·090	29·971	29·764	53·7	43·3	6	29·786	29·853	29·794	29·744	48·8	38·9
7	29·635	29·841	29·731	29·486	54·8	44·4	7	29·684	29·606	29·299	29·141	45·7	35·6
8	29·501	29·481	29·366	29·279	49·2	40·9	8	29·063	29·026	28·736	28·771	42·8	33·0
9	29·163	29·251	29·442	29·549	52·1	40·5	9	28·880	29·037	29·151	29·287	42·9	36·4
10	29·588	29·663	29·581	29·470	49·8	36·6	10	29·358	29·375	29·276	29·330	41·3	34·3
11	29·502	29·677	29·833	29·963	46·7	34·6	11	29·457	29·660	29·807	29·920	45·8	32·8
12	30·013	30·062	30·023	29·969	40·9	28·5	12	29·966	30·042	30·048	30·094	40·3	25·8
13	29·926	29·933	29·919	29·933	45·0	39·2	13	30·119	30·177	30·207	30·255	42·0	28·2
14	29·896	29·890	29·863	29·858	41·3	36·2	14	30·246	30·225	30·150	30·097	42·0	27·2
15	29·806	29·762	29·640	29·382	41·9	36·0	15	29·943	29·790	29·553	29·416	41·0	32·7
16	29·095	29·126	29·307	29·536	39·6	33·2	16	29·391	29·543	29·747	29·889	40·4	34·0
17	29·739	29·877	29·934	29·985	40·9	29·6	17	29·923	29·942	29·889	29·858	39·1	32·4
18	29·999	30·001	29·874	29·678	42·3	24·6	18	29·764	29·690	29·443	29·247	46·7	34·2
19	29·451	29·521	29·460	29·369	47·6	37·5	19	29·221	29·215	29·144	29·113	41·9	33·6
20	29·271	29·369	29·366	29·378	45·8	35·6	20	29·112	29·184	29·213	29·525	38·7	31·9
21	29·568	29·804	29·835	29·809	43·3	33·9	21	29·688	29·742	29·643	29·490	41·7	34·7
22	29·588	29·547	29·483	29·513	53·5	39·9	22	29·264	29·138	29·145	29·274	51·7	38·5
23	29·535	29·564	29·436	29·282	55·1	52·3	23	29·258	29·184	29·007	28·992	50·8	45·4
24	29·188	29·285	29·395	29·397	53·1	44·5	24	28·954	28·988	28·944	28·948	46·0	35·7
25	29·324	29·304	29·288	29·267	47·5	39·7	25	28·933	28·928	28·784	28·831	41·2	34·4
26	29·271	29·340	29·399	29·564	47·6	39·6	26	28·912	29·045	29·244	29·453	43·8	34·0
27	29·697	29·826	29·780	29·791	43·6	35·3	27	29·567	29·555	29·597	29·714	40·1	32·8
28	29·832	30·018	30·134	30·127	42·2	31·7	28	29·911	30·061	30·026	29·817	40·0	32·9
29	29·862	29·702	29·718	29·774	46·0	33·5	29	29·647	29·700	29·724	29·953	41·1	31·8
30	29·893	30·070	30·108	30·088	43·5	30·5	30	30·094	30·167	30·123	30·038	41·0	32·3

DECEMBER, 1882.

1	30·018	29·951	29·896	29·959	32·7	26·5	1	29·922	29·892	29·886	29·927	36·8	33·0
2	30·036	30·070	29·998	29·856	36·2	25·0	2	29·903	29·754	29·495	29·307	43·1	33·3
3	29·628	29·509	29·316	29·084	50·4	34·8	3	29·223	29·177	29·028	28·960	44·4	37·8
4	29·023	29·077	29·090	29·064	50·2	38·0	4	28·879	28·915	29·003	29·153	39·7	33·1
5	29·044	29·046	29·073	29·152	39·5	35·2	5	29·290	29·437	29·525	29·564	33·9	28·6
6	29·195	29·203	29·125	29·086	37·3	32·1	6	29·561	29·552	29·524	29·509	30·1	27·3
7	29·100	29·166	29·134	29·091	34·2	29·0	7	29·483	29·483	29·505	29·589	34·9	27·3
8	29·113	29·283	29·373	29·485	37·1	33·4	8	29·624	29·685	29·680	29·678	35·2	26·8
9	29·551	29·676	29·691	29·732	38·0	27·5	9	29·655	29·681	29·683	29·703	35·9	26·1
10	29·729	29·750	29·717	29·732	28·6	23·7	10	29·683	29·691	29·641	29·630	33·9	25·9
11	——	29·758	29·732	29·720	27·6	22·4	11	29·623	29·663	29·649	29·636	30·1	23·0
12	——	29·701	29·633	29·586	33·3	27·1	12	29·633	29·648	29·625	29·656	25·8	18·3
13	29·511	29·515	29·533	29·606	44·1	33·0	13	29·636	29·639	29·612	29·664	26·4	16·9
14	29·650	29·683	29·691	29·752	40·2	36·6	14	29·712	29·778	29·798	29·822	25·2	20·1
15	29·808	29·848	29·849	29·877	40·7	36·6	15	29·834	29·837	29·796	29·801	35·1	14·3
16	29·874	29·872	29·819	29·822	46·9	35·8	16	29·786	29·804	29·753	29·698	40·9	35·1
17	29·833	29·874	29·807	29·681	49·2	45·3	17	29·660	29·657	29·650	29·652	42·7	37·8
18	29·612	29·636	29·648	29·747	48·4	40·5	18	29·550	29·584	29·652	29·760	44·3	38·8
19	29·845	30·011	30·096	30·210	51·6	33·7	19	29·861	29·981	30·025	30·085	43·2	39·7
20	30·282	30·300	30·244	30·163	47·6	31·1	20	30·079	30·023	29·842	29·678	47·0	40·0
21	29·991	29·883	29·890	29·917	48·0	38·6	21	29·513	29·471	29·531	29·559	46·0	38·3
22	29·860	29·775	29·571	29·434	44·1	34·8	22	29·558	29·493	29·281	29·224	42·3	35·3
23	29·434	29·569	29·621	29·734	42·4	34·5	23	29·330	29·456	29·573	29·622	39·5	29·6
24	29·756	29·848	29·865	29·834	39·5	31·9	24	29·674	29·633	29·614	29·569	39·2	31·3
25	29·667	29·588	29·460	29·470	52·5	37·5	25	29·496	29·453	29·387	29·374	40·2	33·0
26	29·350	29·367	29·530	29·568	53·1	48·9	26	29·303	29·419	29·487	29·480	35·3	31·5
27	29·491	29·544	29·594	29·642	56·9	48·6	27	29·295	29·213	29·146	29·157	48·7	32·7
28	29·657	29·723	29·758	29·725	55·3	50·3	28	29·241	29·324	29·343	29·184	50·9	46·3
29	29·625	29·568	29·511	29·563	53·8	50·3	29	29·161	29·096	29·041	29·400	50·9	33·2
30	29·679	29·659	29·613	29·800	53·8	47·4	30	29·636	29·686	29·687	29·750	37·4	31·9
31	29·891	29·885	29·755	29·778	52·6	46·8	31	29·707	29·662	29·631	29·618	42·8	16·1

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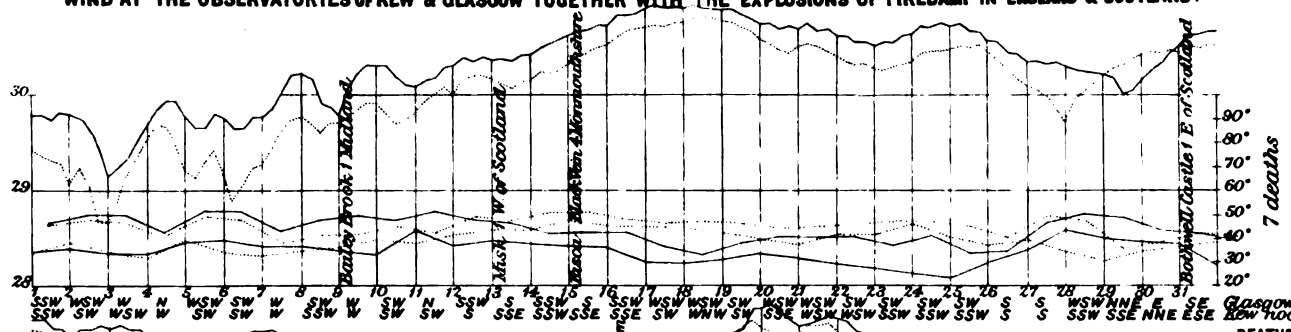
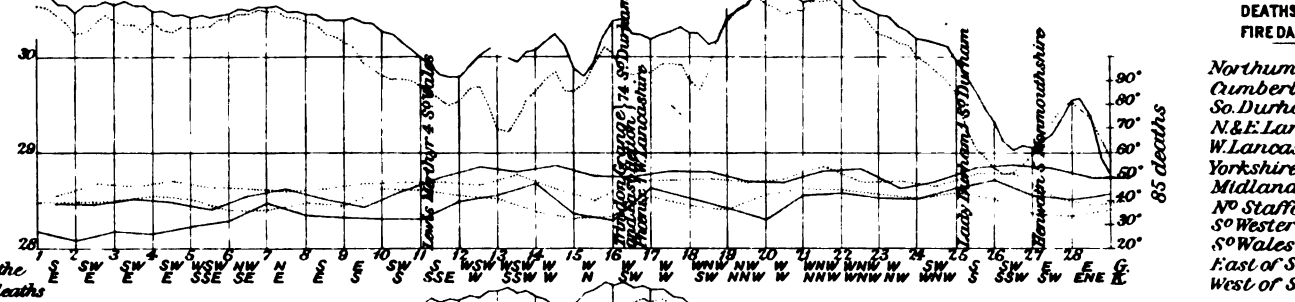
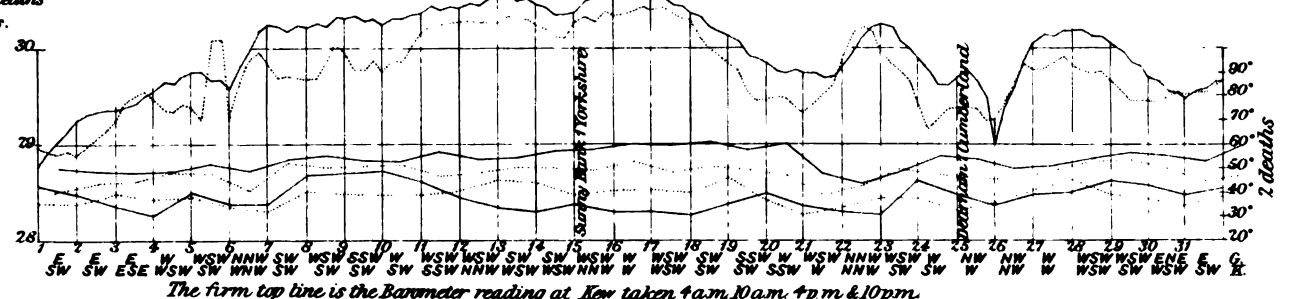
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1882.





Kew lines are firm Glasgow .. dotted The figures attached to the districts shew the Nos of deaths caused by the explosions.



DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1882.

Northumberland	0 deaths
Cumberland	6 "
So. Durham	126 "
N. & E. Lancashire	2 "
W. Lancashire & N. Wales	3 "
Yorkshire	10 "
Midland	70 "
No Staffordshire &c	2 "
So Western Monmouth &c	11 "
So Wales	8 "
East of Scotland	7 "
West of Scotland	1 "
	245

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

And.w Reid, Newcastle

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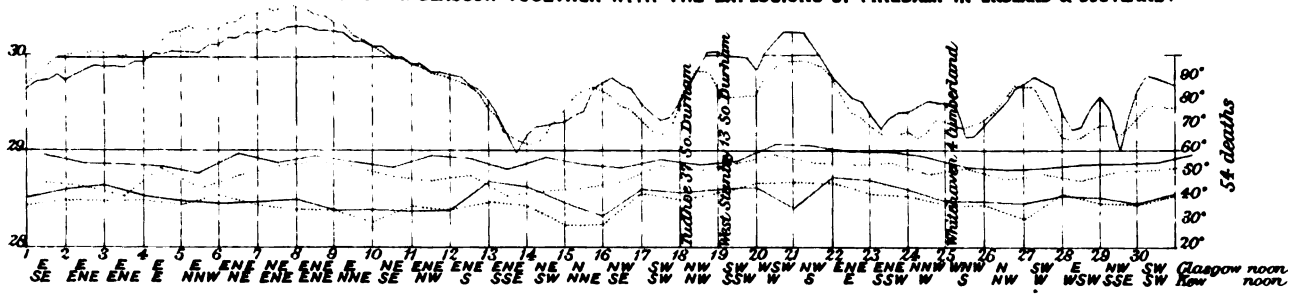
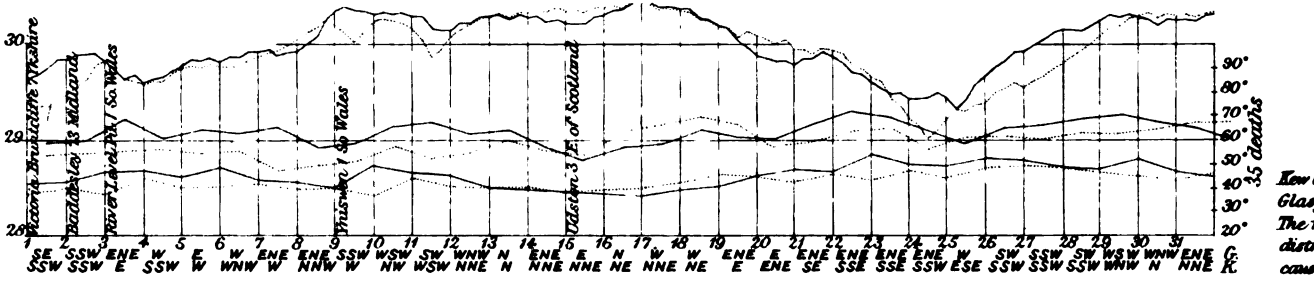
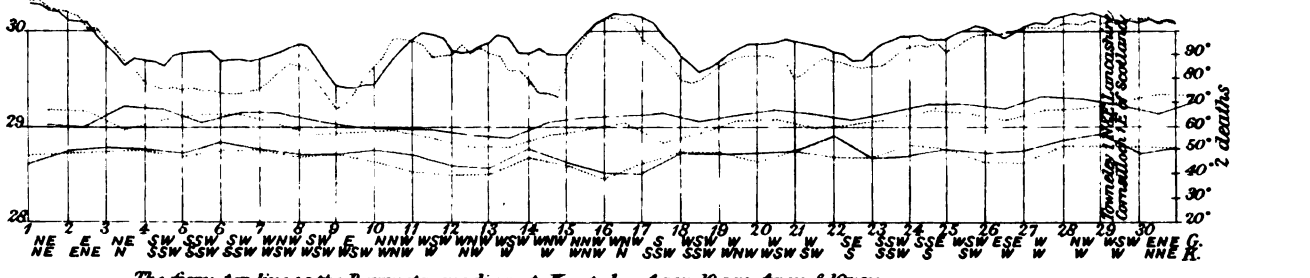
WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1882.





Kew lines are firm
Glasgow " dotted
The figures attached to the districts shew the N° of deaths caused by the explosions.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

And.r Reid, Newcastle

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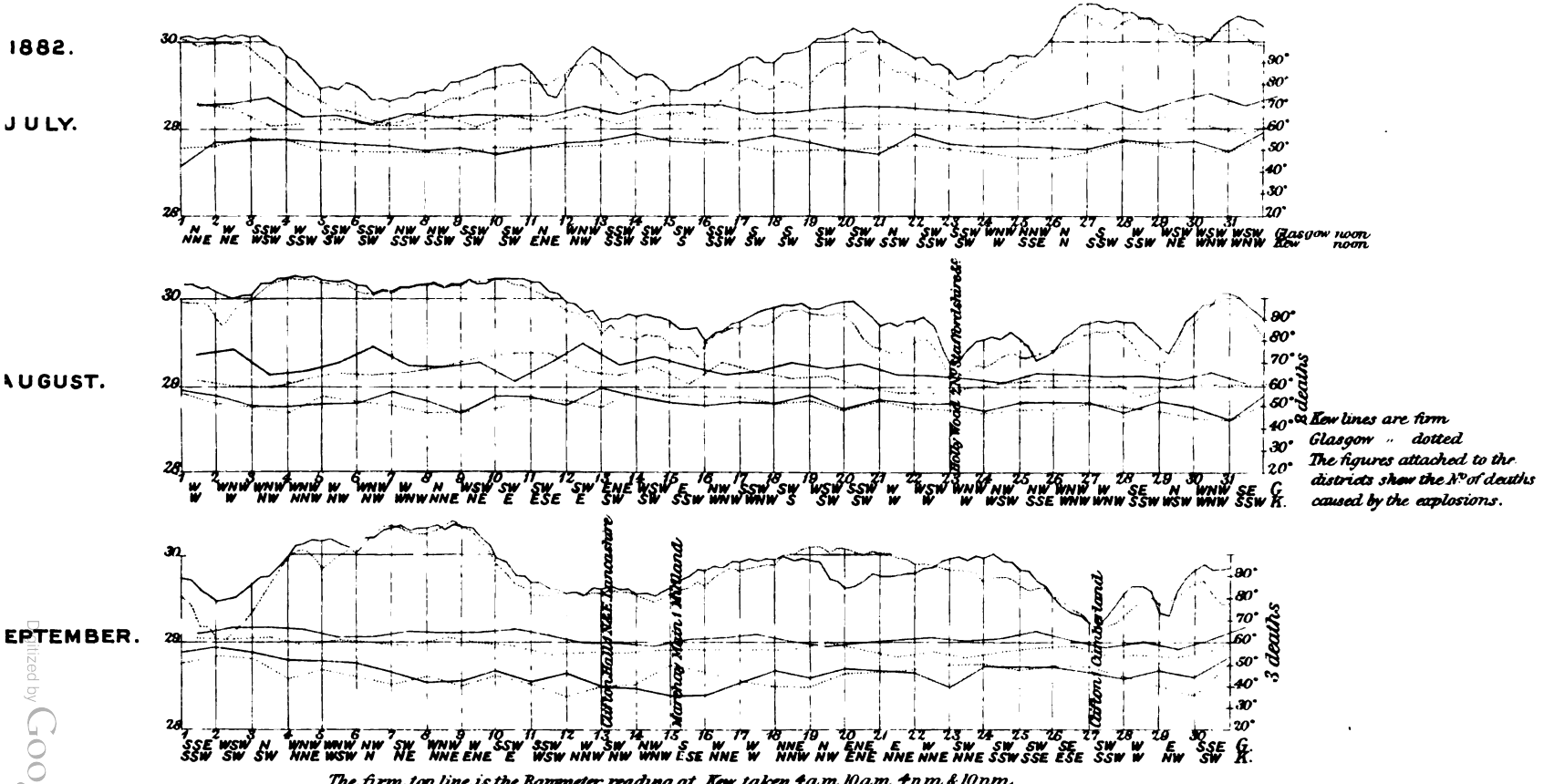
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

Proceedings N.o E.I. of M.&M.E. 1882 83.

And.w Reid Newcastle

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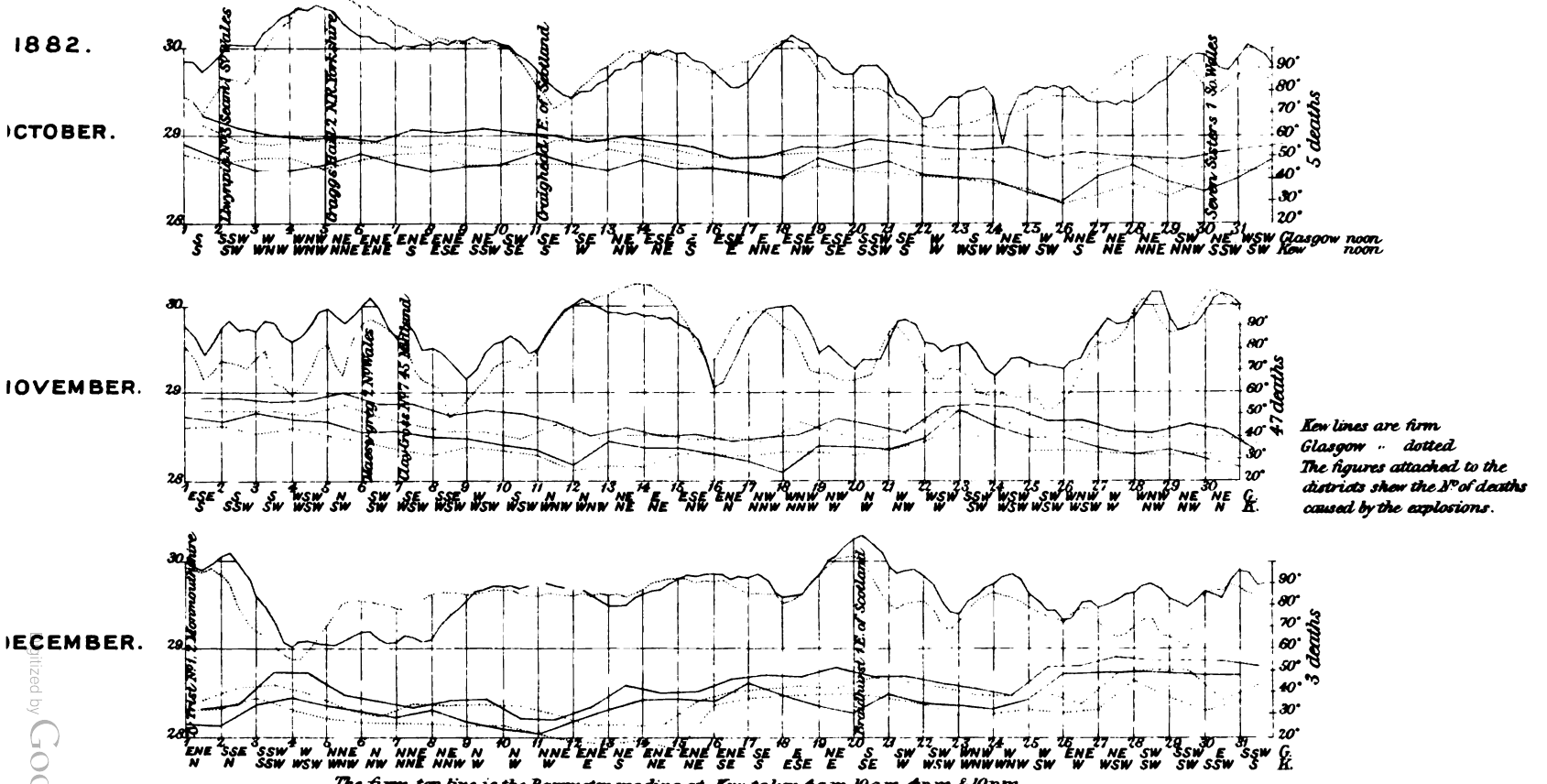
...SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

Andw Reid, Newcastle

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BAROMETER READINGS, &c.

SEPTEMBER, 1882.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·754	29·718	29·630	29·548	65·4	56·0	1	29·545	29·429	29·188	29·171	61·8	51·9
2	29·493	29·495	29·514	29·604	67·5	57·9	2	29·024	29·031	29·153	29·234	62·0	54·2
3	29·688	29·745	29·771	29·875	68·0	56·4	3	29·354	29·537	29·700	29·873	63·4	52·8
4	29·979	30·109	30·147	30·197	66·6	53·2	4	29·981	30·065	30·056	29·985	59·4	44·8
5	30·176	30·192	30·126	30·105	61·9	52·6	5	29·859	29·931	30·003	30·088	61·0	48·1
6	——	30·207	30·214	30·302	62·6	51·8	6	30·035	30·142	30·283	30·343	60·3	45·3
7	30·324	30·354	30·304	30·323	65·1	47·1	7	30·345	30·347	30·284	30·254	59·2	42·3
8	30·321	30·315	30·317	30·359	64·6	42·9	8	30·250	30·314	30·340	30·390	62·0	45·1
9	30·340	30·316	30·211	30·158	64·8	42·7	9	30·345	30·286	30·149	30·074	60·4	40·6
10	30·020	29·944	29·807	29·776	66·2	47·9	10	29·918	29·802	29·686	29·636	57·3	45·8
11	29·711	29·690	29·629	29·625	64·5	43·0	11	29·564	29·562	29·553	29·582	55·3	42·3
12	29·590	29·596	29·579	29·633	59·5	47·0	12	29·578	29·588	29·569	29·596	56·3	35·9
13	29·635	29·664	29·634	29·626	59·5	40·5	13	29·588	29·619	29·600	29·606	56·2	41·0
14	29·587	29·585	29·571	29·605	57·8	39·9	14	29·552	29·520	29·476	29·521	56·8	42·2
15	29·632	29·716	29·763	29·826	61·7	36·5	15	29·563	29·635	29·653	29·706	57·6	51·3
16	29·830	29·885	29·878	29·930	63·5	37·0	16	29·685	29·759	29·807	29·872	56·8	48·0
17	29·931	29·971	29·949	29·983	63·8	42·7	17	29·853	29·879	29·893	29·920	57·0	43·2
18	29·981	29·990	29·966	29·979	60·7	47·9	18	29·926	30·002	30·028	30·096	57·3	40·1
19	29·959	29·927	29·759	29·711	58·0	44·6	19	30·115	30·115	30·051	30·094	59·8	41·0
20	29·644	29·662	29·713	29·791	60·5	48·9	20	30·068	30·050	30·000	30·040	56·7	46·9
21	29·781	29·770	29·770	29·806	61·3	48·0	21	30·015	30·022	29·976	29·968	54·3	47·3
22	29·810	29·861	29·873	29·948	61·2	46·7	22	29·922	29·912	29·873	29·868	55·7	49·4
23	29·965	29·993	29·971	30·005	61·0	39·8	23	29·845	29·851	29·833	29·810	54·0	50·9
24	29·993	30·012	29·944	29·925	62·5	48·8	24	29·733	29·758	29·758	29·738	55·8	51·4
25	29·853	29·822	29·715	29·653	66·1	49·9	25	29·674	29·601	29·622	29·626	58·4	49·6
26	29·516	29·439	29·373	29·309	60·8	49·8	26	29·539	29·492	29·388	29·322	59·4	50·0
27	29·208	29·202	29·315	29·476	57·7	46·8	27	29·210	29·181	29·188	29·225	54·0	50·0
28	29·583	29·669	29·668	29·611	60·5	43·7	28	29·307	29·418	29·496	29·501	55·2	45·1
29	29·359	29·318	29·607	29·746	56·7	47·8	29	29·455	29·477	29·532	29·634	53·9	40·8
30	29·836	29·904	29·840	29·840	61·2	45·2	30	29·687	29·716	29·548	29·458	57·2	36·0

OCTOBER, 1882.

1	29·859	29·848	29·739	29·801	68·6	55·9	1	29·456	29·392	29·230	29·421	66·1	51·3
2	29·920	30·031	30·034	30·037	64·1	49·6	2	29·578	29·653	29·632	29·598	58·1	48·0
3	30·050	30·186	30·248	30·352	61·0	45·0	3	29·719	29·926	30·101	30·208	55·8	49·0
4	30·395	30·439	30·426	30·486	57·9	44·7	4	30·292	30·438	30·499	30·575	58·0	49·7
5	30·461	30·424	30·303	30·234	59·1	46·8	5	30·581	30·611	30·560	30·544	57·3	44·1
6	30·150	30·140	30·084	30·057	58·2	52·1	6	30·479	30·474	30·385	30·363	56·9	49·5
7	30·002	30·052	30·028	30·060	63·4	47·4	7	30·261	30·224	30·157	30·123	54·8	50·8
8	30·052	30·078	30·052	30·093	62·5	43·6	8	30·071	30·111	30·084	30·081	57·2	52·0
9	30·098	30·130	30·097	30·103	63·6	46·4	9	30·045	30·047	30·039	30·050	54·8	45·9
10	30·064	30·042	29·940	29·884	61·0	47·2	10	30·027	30·010	29·875	29·746	53·3	46·0
11	29·779	29·653	29·520	29·467	60·1	51·8	11	29·594	29·490	29·311	29·376	57·9	48·4
12	29·457	29·488	29·509	29·599	56·7	47·6	12	29·439	29·540	29·617	29·728	58·7	47·3
13	29·653	29·739	29·780	29·854	59·9	45·5	13	29·786	29·872	29·928	29·972	57·5	54·2
14	29·879	29·936	29·958	29·986	56·8	48·8	14	29·954	29·971	29·943	29·901	55·2	52·1
15	29·956	29·946	29·873	29·834	55·0	45·2	15	29·837	29·801	29·767	29·734	52·1	46·8
16	29·724	29·637	29·551	29·551	49·1	45·7	16	29·719	29·774	29·778	29·824	50·2	45·0
17	29·605	29·741	29·878	29·998	49·8	43·6	17	29·854	29·931	29·971	30·047	51·5	41·8
18	30·055	30·126	30·084	30·050	55·3	41·5	18	30·084	30·092	30·009	29·912	52·3	39·9
19	29·939	29·864	29·736	29·694	55·4	48·8	19	29·743	29·624	29·531	29·537	52·7	46·0
20	29·707	29·804	29·794	29·800	59·1	44·9	20	29·526	29·541	29·516	29·526	54·4	44·0
21	29·702	29·490	29·423	29·350	57·4	47·8	21	29·477	29·394	29·231	29·171	51·4	43·2
22	29·174	29·211	29·355	29·432	55·0	42·3	22	29·107	29·060	29·073	29·112	49·5	40·9
23	29·435	29·493	29·512	29·549	54·0	41·1	23	29·108	29·131	29·136	29·215	49·8	41·0
24	29·470	28·910	29·255	29·458	55·6	39·5	24	29·252	29·237	29·216	29·365	47·6	37·8
25	29·497	29·546	29·532	29·553	51·3	33·6	25	29·322	29·375	29·416	29·451	50·2	35·8
26	29·535	29·546	29·460	29·395	51·6	29·9	26	29·429	29·441	29·426	29·465	43·7	29·1
27	29·373	29·377	29·343	29·379	50·8	40·8	27	29·530	29·621	29·685	29·779	49·0	32·8
28	29·369	29·425	29·504	29·596	49·7	46·6	28	29·841	29·905	29·915	29·929	49·3	36·9
29	29·639	29·741	29·840	29·919	49·9	38·5	29	29·889	29·861	29·815	29·723	44·8	33·1
30	29·914	29·842	29·752	29·730	52·9	34·6	30	29·565	29·501	29·491	29·562	44·6	38·9
31	29·894	30·022	29·997	29·939	55·5	40·6	31	29·648	29·772	29·771	29·711	50·4	42·7

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BAROMETER READINGS, &c.

NOVEMBER, 1882.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·799	29·614	29·427	29·587	57·5	49·3	1	29·524	29·371	29·172	29·210	52·0	44·9
2	29·768	29·822	29·725	29·738	56·7	46·8	2	29·367	29·350	29·320	29·298	51·6	45·3
3	29·724	29·851	29·812	29·668	56·0	50·8	3	29·392	29·468	29·108	29·057	51·8	43·2
4	29·570	29·644	29·752	29·930	56·9	48·1	4	29·968	29·083	29·279	29·478	50·0	44·1
5	29·979	29·916	29·814	29·862	59·8	47·5	5	29·534	29·322	29·201	29·618	54·7	41·9
6	30·012	30·090	29·971	29·764	53·7	43·3	6	29·796	29·853	29·794	29·744	48·8	38·9
7	29·635	29·841	29·731	29·486	54·8	44·4	7	29·684	29·606	29·299	29·141	45·7	35·6
8	29·501	29·481	29·306	29·279	49·2	40·9	8	29·083	29·026	28·736	28·771	42·8	33·0
9	29·163	29·251	29·442	29·549	52·1	40·5	9	28·880	29·037	29·151	29·287	42·9	36·4
10	29·588	29·663	29·581	29·470	49·8	36·6	10	29·358	29·375	29·276	29·330	41·3	34·3
11	29·502	29·677	29·833	29·963	46·7	34·6	11	29·457	29·660	29·807	29·920	45·8	32·8
12	30·013	30·062	30·023	29·989	40·9	28·5	12	29·966	30·042	30·048	30·094	40·3	25·8
13	29·926	29·933	29·919	29·933	45·0	39·2	13	30·119	30·177	30·207	30·255	42·0	28·2
14	29·896	29·890	29·863	29·858	41·3	36·2	14	30·246	30·225	30·150	30·097	42·0	27·2
15	29·806	29·762	29·640	29·382	41·9	36·0	15	29·943	29·790	29·553	29·416	41·0	32·7
16	29·095	29·126	29·307	29·536	39·6	33·2	16	29·391	29·543	29·747	29·889	40·4	34·0
17	29·739	29·877	29·934	29·985	40·9	29·6	17	29·923	29·942	29·889	29·858	39·1	32·4
18	29·999	30·001	29·874	29·678	42·3	24·6	18	29·764	29·690	29·443	29·247	46·7	34·2
19	29·451	29·521	29·460	29·369	47·6	37·5	19	29·221	29·215	29·144	29·113	41·9	33·6
20	29·271	29·369	29·366	29·378	45·8	35·6	20	29·142	29·184	29·213	29·525	38·7	31·9
21	29·568	29·804	29·835	29·809	43·3	33·9	21	29·688	29·743	29·643	29·490	41·7	34·7
22	29·588	29·547	29·483	29·513	53·5	39·9	22	29·264	29·138	29·145	29·274	51·7	38·5
23	29·535	29·564	29·436	29·282	55·1	52·3	23	29·258	29·184	29·007	28·992	50·8	45·4
24	29·188	29·285	29·395	29·397	53·1	44·5	24	28·954	28·988	28·944	28·948	46·0	35·7
25	29·324	29·304	29·288	29·267	47·5	39·7	25	28·933	28·928	28·784	28·831	41·2	34·4
26	29·271	29·340	29·399	29·564	47·6	39·6	26	28·912	29·045	29·244	29·453	43·8	34·0
27	29·697	29·826	29·780	29·791	43·6	35·3	27	29·567	29·555	29·597	29·714	40·1	32·8
28	29·832	30·018	30·134	30·127	42·2	31·7	28	29·911	30·061	30·026	29·817	40·0	32·9
29	29·862	29·702	29·718	29·774	46·0	33·5	29	29·647	29·700	29·724	29·953	41·1	31·8
30	29·893	30·070	30·108	30·088	43·5	30·5	30	30·094	30·167	30·123	30·038	41·0	32·3

DECEMBER, 1882.

1	30·018	29·951	29·896	29·959	32·7	26·5	1	29·922	29·892	29·886	29·927	36·8	33·0
2	30·036	30·070	29·998	29·856	36·2	25·0	2	29·903	29·754	29·495	29·307	43·1	33·3
3	29·628	29·509	29·316	29·084	50·4	31·8	3	29·223	29·177	29·028	28·960	44·4	37·8
4	29·023	29·077	29·090	29·064	50·2	38·0	4	28·879	28·915	29·003	29·153	39·7	33·1
5	29·044	29·046	29·073	29·152	39·5	35·2	5	29·290	29·437	29·525	29·564	33·9	28·6
6	29·195	29·203	29·125	29·096	37·3	32·1	6	29·561	29·552	29·524	29·509	30·1	27·3
7	29·100	29·166	29·134	29·091	34·2	29·0	7	29·483	29·483	29·505	29·589	34·9	27·3
8	29·113	29·283	29·373	29·485	37·1	33·4	8	29·624	29·685	29·680	29·678	35·2	26·8
9	29·551	29·676	29·691	29·732	38·0	27·5	9	29·655	29·681	29·683	29·703	35·9	26·1
10	29·729	29·750	29·717	29·732	28·6	23·7	10	29·683	29·691	29·641	29·630	33·9	25·9
11	——	29·758	29·732	29·720	27·6	22·4	11	29·623	29·663	29·649	29·636	30·1	23·0
12	——	29·701	29·633	29·586	33·3	27·1	12	29·633	29·648	29·625	29·656	25·8	18·3
13	29·511	29·515	29·533	29·606	44·1	33·0	13	29·636	29·639	29·612	29·664	26·4	16·9
14	29·650	29·683	29·691	29·752	40·2	36·6	14	29·712	29·778	29·798	29·822	25·2	20·1
15	29·808	29·848	29·849	29·877	40·7	36·6	15	29·834	29·837	29·796	29·801	35·1	14·3
16	29·874	29·872	29·819	29·822	46·9	35·8	16	29·786	29·804	29·753	29·698	40·9	35·1
17	29·833	29·874	29·807	29·681	49·2	45·3	17	29·660	29·657	29·650	29·652	42·7	37·8
18	29·612	29·626	29·648	29·747	48·4	40·5	18	29·550	29·584	29·652	29·760	44·3	38·8
19	29·845	30·011	30·096	30·210	51·6	33·7	19	29·861	29·981	30·025	30·065	43·2	39·7
20	30·282	30·300	30·244	30·163	47·6	31·1	20	30·079	30·023	29·842	29·678	47·0	40·0
21	29·991	29·883	29·890	29·917	48·0	38·6	21	29·513	29·471	29·531	29·559	46·0	38·3
22	29·860	29·775	29·571	29·434	44·1	34·8	22	29·558	29·493	29·281	29·224	42·3	35·3
23	29·434	29·569	29·621	29·724	42·4	34·5	23	29·330	29·456	29·573	29·622	39·5	29·6
24	29·756	29·848	29·865	29·834	39·5	31·9	24	29·674	29·633	29·614	29·569	39·2	31·3
25	29·667	29·588	29·460	29·470	52·5	37·5	25	29·496	29·453	29·387	29·374	40·2	33·0
26	29·350	29·367	29·530	29·568	53·1	48·9	26	29·303	29·419	29·487	29·490	35·3	31·5
27	29·491	29·544	29·594	29·642	56·9	48·6	27	29·295	29·213	29·146	29·157	48·7	32·7
28	29·657	29·723	29·758	29·725	55·3	50·3	28	29·241	29·324	29·343	29·184	50·9	46·3
29	29·625	29·568	29·511	29·563	53·8	50·3	29	29·161	29·096	29·041	29·400	50·9	33·2
30	29·679	29·659	29·613	29·800	53·8	47·4	30	29·636	29·686	29·687	29·750	37·4	31·9
31	29·891	29·885	29·755	29·778	52·6	46·8	31	29·707	29·662	29·631	29·618	42·8	16·1

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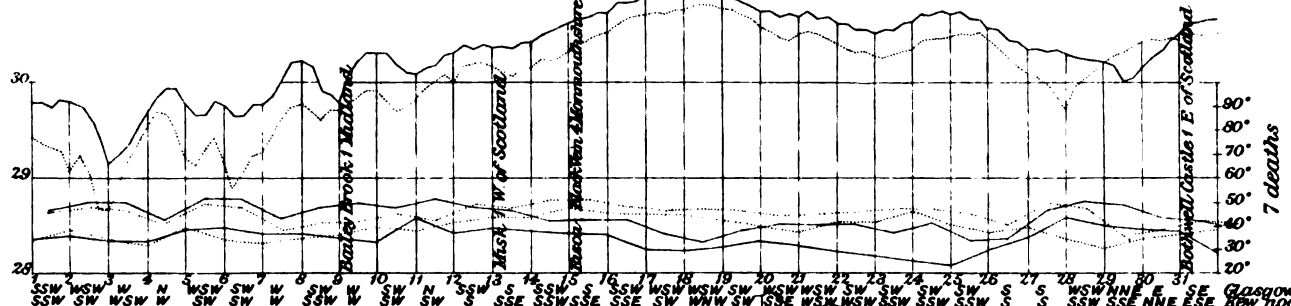
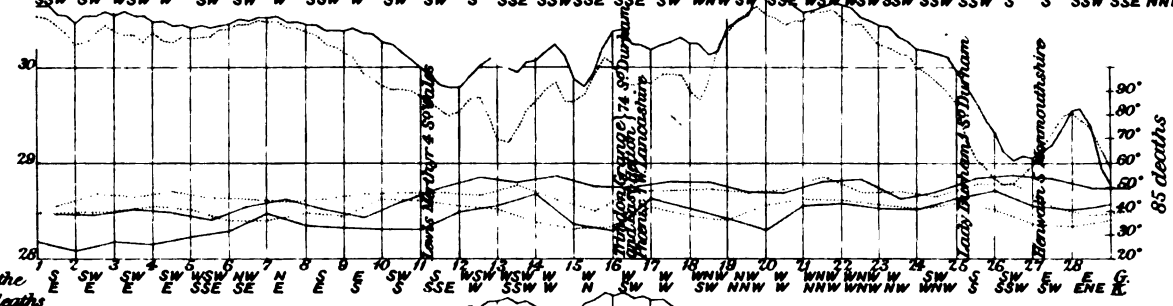
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1882.

JANUARY.

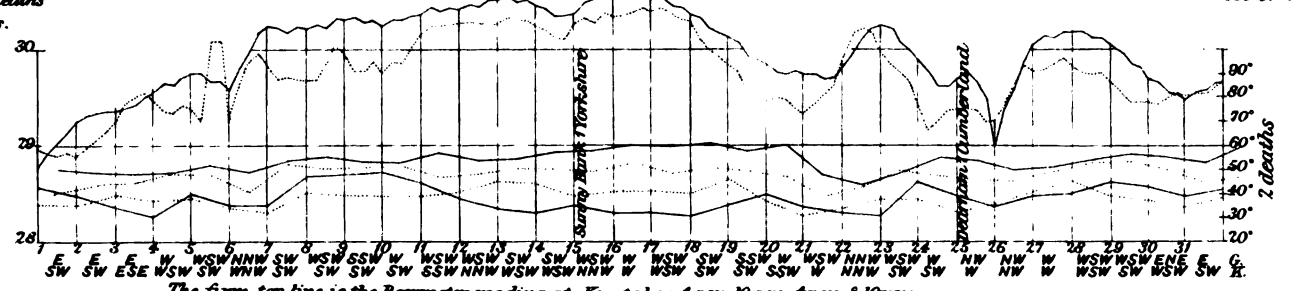


FEBRUARY.



Kew lines are firm
Glasgow .. dotted
The figures attached to the districts shew the Nº of deaths caused by the explosions.

MARCH.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1882.

Northumberland	0 deaths
Cumberland	6 "
So. Durham	125 "
N. & E. Lancashire	2 "
W. Lancashire & N. Wales	3 "
Yorkshire	10 "
Midland	70 "
Nº Staffordshire &c	2 "
Sº Western Monmouth &c	11 "
Sº Wales	8 "
East of Scotland	7 "
West of Scotland	1 "
	245

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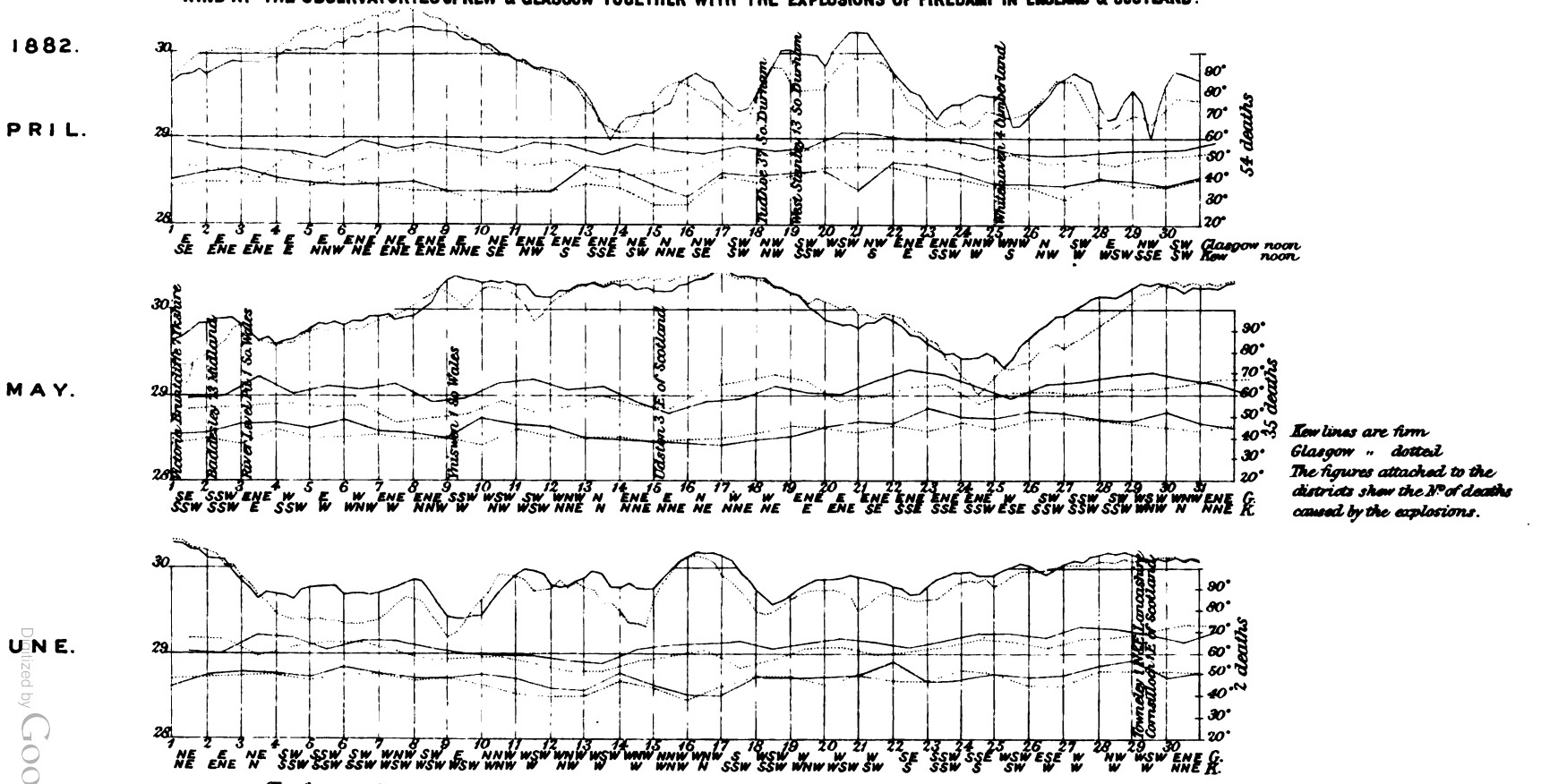
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.



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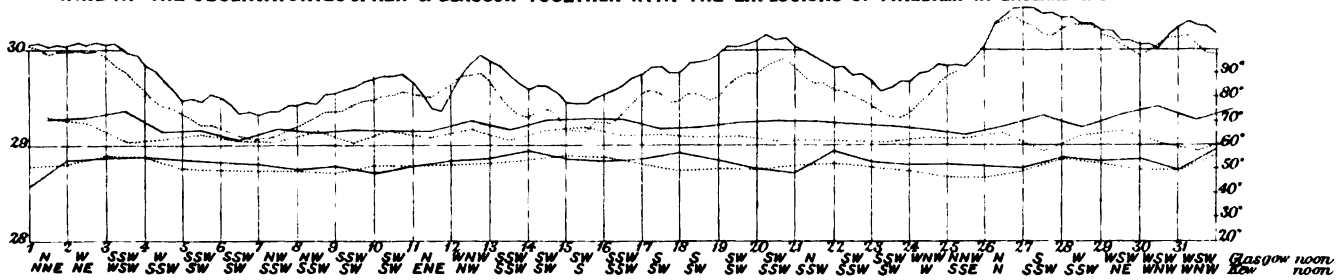
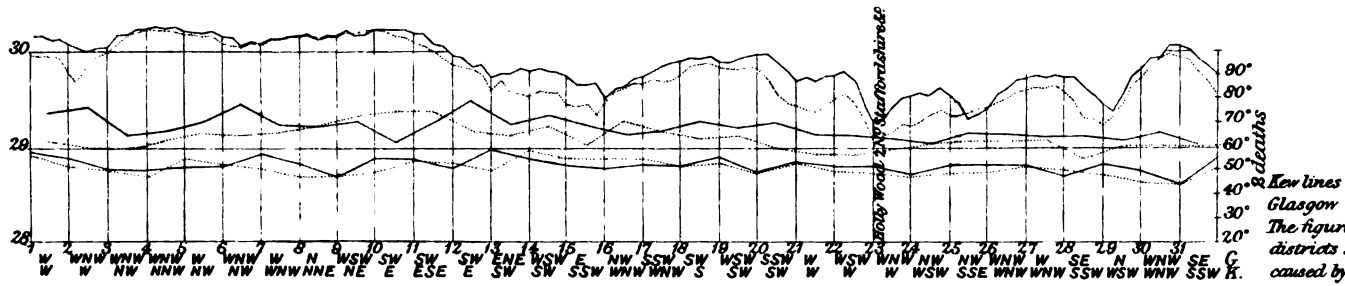
1882.

JULY.

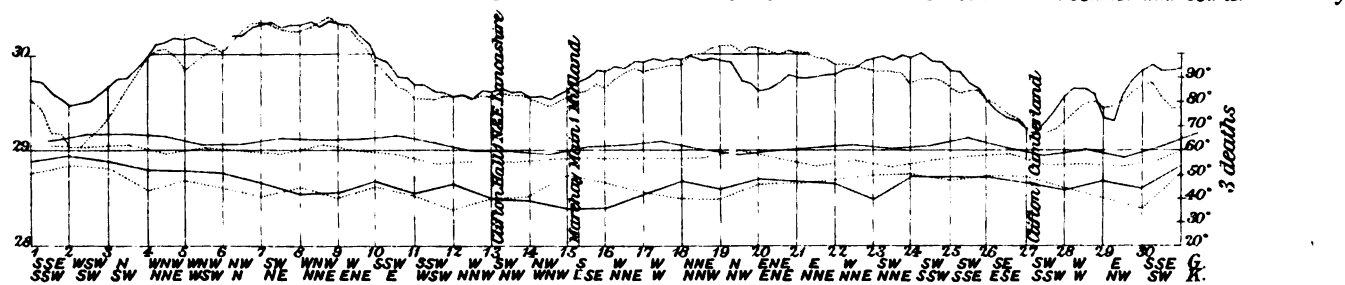


AUGUST.



Kew lines are firm
Glasgow " dotted
The figures attached to the districts shew the N° of deaths caused by the explosions.

EPTEMBER.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

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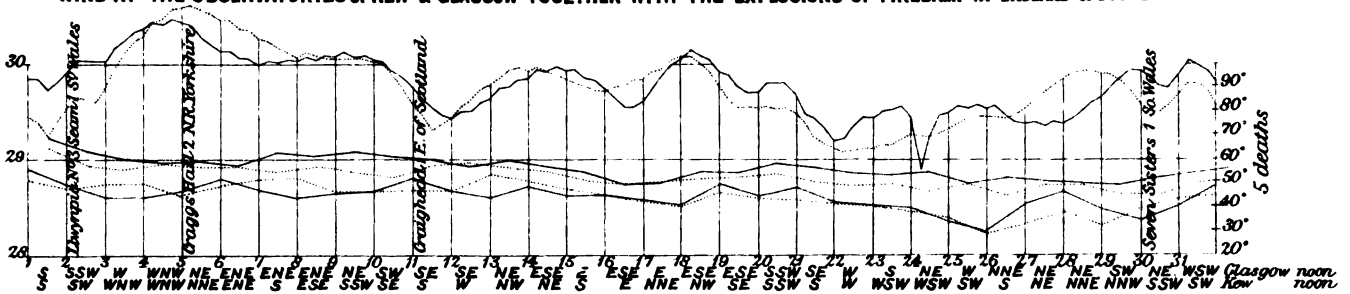
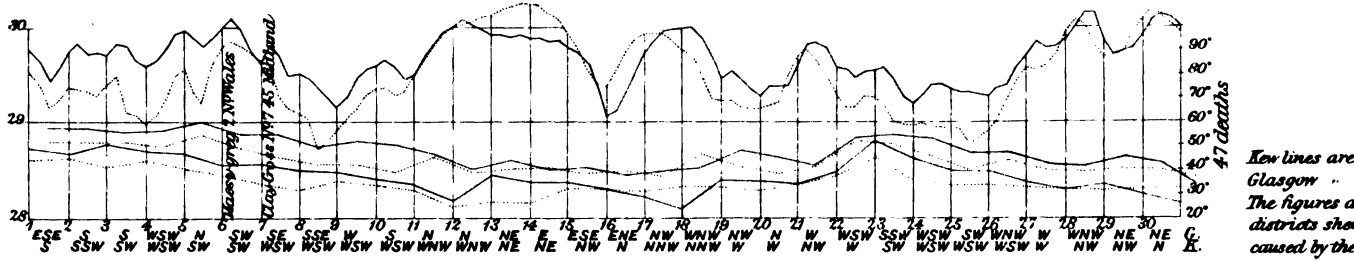
DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1882.

OCTOBER.

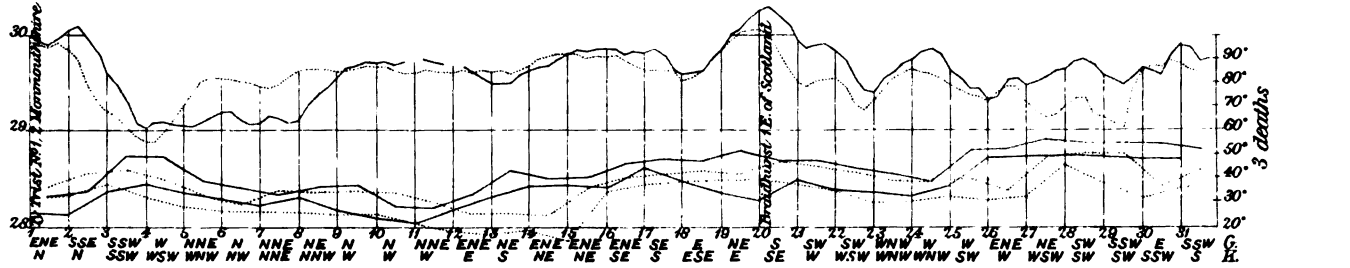


NOVEMBER.



Kew lines are firm
Glasgow .. dotted
The figures attached to the districts shew the N° of deaths caused by the explosions.

DECEMBER.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

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APPENDIX.

COAL STATISTICS FROM THE MINES INSPECTORS' REPORTS, FROM 1851 TO 1881, WITH AN ABSTRACT OF THE INSPECTORS' REMARKS FOR 1881.

STATISTICS RELATING TO COAL MINING IN GREAT BRITAIN.

PREFACE.

It is very much to be regretted that no records of statistics relating to coal mining proper are prepared. The production of coal since the year 1854 can be obtained with more or less accuracy in Mr. Hunt's Mineral Statistics and in Her Majesty's Inspectors of Mines Reports from 1865; also a list of the collieries in the kingdom can be obtained in Mr. Hunt's publication from 1854, but the further information, such as persons employed and deaths by accident in coal mining, necessary to make the statistics complete and comparable cannot be obtained, for coal mining is so mixed up with ironstone (stratified) fireclay and shale mining under the Coal Mines Act of 1872 that it is impossible to separate with any accuracy the persons employed, accidents and deaths caused by accidents under the different heads of mining since 1872; and as before that date, and back as far as 1865 these particulars as to coal mining are in existence in Her Majesty's Inspectors' Reports, the statistical records, even if accurate before 1872, cannot be usefully compared with the reports at present issued, and comparisons—the real use of statistics—cannot be made between the years since 1872 and those before. Before the passing of the Coal Mines Act of 1872 it was not compulsory on the part of mine owners to give information to the Inspectors regarding the output and persons employed, so that the information given in the Inspectors' reports from the year 1865—the first year in which any record is given of production and persons employed in coal mining—up to the passing of the Coal Mines Act cannot be looked upon as very accurate; but as Mr. Hunt supplied independently in his annual publication the production of coal since 1854, this production can be always taken from his books up to 1872; while as to persons employed the Inspectors' reports must, for want of better information, be taken.

The two sets of figures as to production annually supplied by Mr. Hunt and the Inspectors never agreed until 1881, being sometimes very different, arising from the two parties each independently getting the required information. Prior to the year 1872 the accuracy of the reports may be called in question, but since 1872 the production is no doubt as accurately recorded as possible in the Inspectors' reports, and Mr. Hunt probably now takes these figures instead of compiling them himself, since they could never be so accurately obtained from mine owners unless they were obliged by law to give them.

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With regard to persons employed in coal mining since 1872 the number can only be approximately obtained—with some trouble—from the Inspectors' Reports, for the persons employed in working ironstone, shale, and fireclay must be separated from those working coal, which can only be done approximately. Taking the year 1881, Summary No. 1, ironstone mining with the number of persons employed in it, is only kept separate in the North Riding of Yorkshire, Lincolnshire, and East and West Scotland, to the extent of 76·38 per cent. of the total ironstone raised, and the same is the case with shale and fireclay to the extent of 87·16 per cent. and 16·63 per cent. respectively; the rest is so mixed up with coal mining that the persons employed cannot be separated to any further degree. The percentage of these minerals to the total production of minerals under the Coal Mines Act of 1872 is as follows for the year 1881:—Coal, 91·2; ironstone, 7·0; fireclay, 1·2; and shale, 0·6; and after separating what can be done to the extent above stated the percentage of coal is increased to 97 per cent. of the total production. The same applies, but not in the same degree, to the accidents recorded under the Coal Mines Acts, so that it will be seen that with regard to coal mining alone, the statistics are neither accurate or useful as a means of comparison between the various years. It might be said that this inseparable element of 3 per cent. is so small as not to affect in any practical degree the accuracy of the figures embodied in the following report, but when taking into consideration the trouble given to persons trying to separate the items, and the difference that may exist in different years between the separable and the inseparable items, together with what might have been supposed to be one of the objects of the Coal Mines Act—the obtaining of accurate statistics in order that comparisons with other and future years might be possible—the records now published annually can hardly be deemed satisfactory.

Thus the continuity of coal mining statistics was broken in 1872, and what has since been gained in accuracy as to the production is lost by mixing other minerals than coal when considering the persons employed and the deaths by accident, so that all deducible relations such as coals raised per person employed, number of persons killed per 1,000 employed, and number of persons employed per death and tons raised per death in coal mining, now made, are not accurate and, what is worse, cannot be used as comparisons, for the degree of separation now possible will be always altering, defeating the use of one of the most interesting projects of statistics, viz., the recording of the progress of mining in the kingdom.

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EXTRACTS FROM MINES INSPECTORS' REPORTS.

In the following tables, etc., the ironstone, shale, and fireclay mines have, so far as practicable, been separated from the coal mines, but as part of the shale, fireclay, and ironstone is worked in common with the coal, it is impossible from the data given to entirely separate them. The ironstone districts of Cleveland, Lincolnshire, and East and West of Scotland have, however, been tabulated separately, and these districts include, in 1881, 76·38 per cent. of the ironstone production of the Kingdom, 87·16 per cent. of oil shale, and 16·63 per cent. of fireclay, with the corresponding number of persons employed, and the accidents which have occurred in the same mines.

It is also impracticable to give any separate comparison for ironstone, fireclay, and shale, as, although the numbers of men employed are given separately, in nearly all cases the accidents in East and West Scotland are classed together.

EXTRACT FROM 1873 REPORT.—"The oil shale mines are all newly comprised, and so are likewise the iron mines of Cleveland, etc., and numerous blackband ironstone mines, so that no comparison can be made with previous years as to these mines."

*Output.—Coal.**

The output for the year, 1881, was the largest on record, the lowest output since the passing of the Mines Regulation Act, 1872, and previous to 1881, was:—

	Tons.
In the year 1873	131,556,102
And the highest 1880	151,101,815
Total for 1873-1880	1,104,775,390
Average for 1873-1880	138,096,924
The output for 1881	158,472.005

The output for the year, 1881, is nearly 15 per cent. above the average of the previous eight years.

*Output.—Ironstone, Fireclay, and Oil Shale.**

	Tons.
The highest was in the year, 1873	11,485.144
And the lowest 1879	8,289,961
Total for 1873-1880	76,946,936
Average for 1873-1880	9,618.367
The output for 1881	10,487,926

The output for 1881 is 9 per cent. above the average of the previous eight years. 90½ per cent. of the above is ironstone.

*Persons Employed and Tons raised per Person Employed.—Coal.**

The number of persons employed was lower than the average:—

	Persons Employed.	Tons.
The lowest was in 1878	453.843	301
And the highest 1875	510,152	271
Total for 1873-1880	3,826,133	—
Average for 1873-1880	478,268	288
Persons employed in 1881	471,745	336

The number being for the latter year 1·36 per cent. below the average of the previous eight years.

* Subject to remarks in Preface.

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*Persons Employed.—Ironstone, etc.**

The lowest number of persons employed in any one year was in 1879 ... ... 21.462
The highest 1873 ... ... 36.154
Total 1873–1880 ... ... 208.685
Average 1873–1880 26,086
Persons employed in 1881 23,732

The number employed in 1881 is 9·02 per cent. below the average of the previous eight years.

*Separate Fatal Accidents.—Coal.**

These have been a little below the average:—

The lowest having been in 1879 747
And the highest in 1873 911
Total for 1873–1880 6,571
Average for 1873–1880 821
Number in 1881 799

The number being for the latter 2·68 per cent. below the average of the last eight years.

*Separate Fatal Accidents.—Ironstone, etc.**

These are above the average of the previous eight years, the lowest being:—

In the year 1878 28
The highest was in 1873 62
Total from 1873–1880 335
Average for 1873–1880 42
And for 1881 45

Being 7·14 per cent. above the average.

*Lives Lost by the Accidents.—Coal.**

This item has been the lowest except one during the eight years.

The lowest was in 1876 900
And the highest was 1878 1,384
Total for 1873–1880 8,867
Average for 1873–1880 1,108
Those of 1881 909

Being 17·96 per cent. below the average of the last eight years.

*Lives Lost by the Accidents.—Ironstone, etc.**

These are above the average, the lowest being for 1878 28
The highest 1873 66
Total for 1873–1880 347
Average 43
And in 1881 45

Being 4·65 per cent. above the previous eight years.

*Death Rate per 1,000 Persons Employed.—Coal.**

This has been much below the average, the lowest being in 1876 ... ... 1·840
And the highest, 1878 ... ... 3·049
Average for 1873–1880 ... ... 2·317
That for 1881 ... ... 1·927

The death rate for 1881 being 16·83 per cent. below the average of the last eight years.

* Subject to remarks in Preface.

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*Death Rate per 1,000 Persons Employed.—Ironstone, etc., Mines.**

The lowest was in	1875	1·051
The highest	1877	1·923
The average for 1873–1880		1·662
And for	1881	1·896

The latter year being 14·08 per cent. above the previous eight years.

*Tons of Mineral Wrought per Life Lost.—Coal.**

This year is by far the most favourable of any year during the last decade, the lowest previous to 1881 was in the year 1878 ... ... Tons. 98,851

And the highest was in 1876	154,395
Average for 1873–1880	124,594
Tons wrought per life lost in 1881	174,336

Being 39·90 per cent. above the average of the last eight years.

*Tons of Ironstone, Clay, and Shale Worked per Life Lost.**

		Tons.
The lowest was in	1874	165,640
The highest in	1878	320,985
The average for 1873–1880		221,720
And in	1881	233,065

The latter being 4·86 per cent. above the previous eight years.

The Ratio of Persons Employed to each Death in Coal Mines has gone on increasing every decade since 1851 as follows:—

	Per Cent. Increase. Over First.	Over Last.
1851 to 1860 = 245	—	—
1861 „ 1870 = 300	22·45	—
1873 „ 1880 = 431	75·90	42·66
And in 1881 = 519	111·83	20·41

The Ratio of Persons Employed to each Death from Colliery Explosions has increased as follows:—*

	Per Cent. Increase. Over First.	Over Last.
1851 to 1860 = 1,008	--	—
1861 „ 1870 = 1,408	39·68	--
1873 „ 1880 = 1,694	68·05	20·31
And in 1881 = 4,138	310·51	144·27

The lowest during the last eight years being	1878	774
And the highest,	1876	5,203
Average,	1873–1880	1,694
And for	1881	4,138

The ratio being in 1881, 144·27 per cent. higher than the average of the last eight years.

The proportion of deaths from explosions is 24·25 per cent. of the total deaths from all causes.

* Subject to remarks in Preface.

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1876 was remarkably free from serious explosions, there being only one at which more than ten lives were lost, one of six, two of five, and a number of others under four each.

South Wales Colliery, Monmouth	23
Birley Colliery, Sheffield	6
Jammage Colliery, Chesterton	5
Silverdale Colliery, Newcastle, N.S.	5
Under four each...	56
Total	95

1878.—Since the passing of the Mines Inspection Act of 1850, this year has been the heaviest in point of numbers, with the exception of 1866, when there were 651 persons killed by explosions against 586 in 1878.

There were several very disastrous explosions by which the ratio of persons employed per fatal accident was very much reduced.

Unity Brook Colliery, near Manchester	43
Whiston Main Delf Colliery, Prescot, Lancashire	7
Wood Pit (Upper Florida Seam) Haydock, Lancashire	189
Pendwll (Lower Yard Seam) Wrexham, North Wales	6
Apedale Colliery, Newcastle, North Staffordshire	23
Abercarn Colliery, Monmouthshire	268
Barwood (No. 2 Pit) Colliery, Islsyth, Scotland, W.	17
Under four each	33
Total	586

1880.—This year was, in point of numbers killed, the heaviest for the last thirty years, with the exception of 1866 and 1878, there having been 499 lives lost, the bulk of which were at the following collieries, viz.—

Seaham Colliery, Durham	164
Bersham Colliery, Wrexham, North Wales	9
Middleton Colliery, Leeds, Yorkshire	5
Kiverton Park Colliery, Sheffield, Yorkshire	4
Leycett Colliery, Newcastle, Staffordshire	62
Garngoch Colliery, Swansea, South Wales	6
Naval Steam Coal, Penycraig...	101
Bedwellty Pits, Monmouthshire	4
Risca, Black Vein, Monmouthshire	120
Several under four each	24
Total	499

1881.—During this year there have been only two cases of explosion, causing the death of more than 10 persons each, and two of more than 4 each:—

Abercarn Colliery, Wigan, Lancashire	48
Whitfield Colliery, Tunstall, North Staffordshire	25
Lillydale Colliery, Bucknall, do.	8
Shilton Colliery, Hanley do.	4
Under four each	31
Total	116

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Falls of Roof and Sides.—Coal.

This is by far the most fruitful source of accident, and is less subject to fluctuation than any other class to which miners are exposed.

The ratio of persons employed to each death being for—

		Per Cent. Increase.	
		Over First.	Over Last.
1851–1860 =	653	—	—
1861–1870 =	767	17·45	17·45
1873–1880 =	1,104	69·06	43·94
1881 =	1,107	69·52	0·27

The ratio of persons employed per life lost, since the passing of the Mines Regulation Act, 1872, has been as follows:—

The lowest in	1878	993
And the highest in	1874	1,289
Average for	1873–1880	1,104
And for	1881	1,107

The ratio being for the latter year 0·27 per cent. above the average of the previous eight years.

The proportion of deaths from falls of roof is 73½ per cent., and from falls of side 26½ per cent. of the total deaths from falls.

The number of deaths from falls of roof and side is 39·81 per cent. of the deaths from all causes, including explosions.

Falls of Roof and Side, in Iron, etc., Mines.—Falls of roof and side are the causes of a large proportion of deaths, the average of the eight years being:—

	Per Cent.	
1873–1880	43	of the total deaths.
For 1881	54	do.

The ratio of the persons employed to each death being:—

For 1873–1880	1,391
1881	989

Making a decrease of 40·64 per cent. on the average of the previous eight years.

Miscellaneous Underground Accidents.—Coal;

Are the next in importance, and they have slightly increased in proportion to the persons employed as compared with the average of the previous eight years.

The ratio of persons employed to each death being:—

		Percentage Over or Under	
		First Year.	Last Year.
1851–1860 =	2,074	—	—
1861–1870 =	1,666	19·67 under	—
1873–1880 =	2,718	31·05 over	63·14 over
1881 =	2,606	25·65 over	4·12 under

The ratio of persons employed to each life lost since the passing of the Mines Regulation Act, 1872, has been as follows, viz.:—

The lowest was in	1873	2,366
The highest in	1876	3,420
Average for	1873–1880	2,718
And for	1881	2,606

The ratio being 4·12 per cent. worse than the previous eight years.

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The deaths from the various causes comprised under this head are 16·25 per cent. of the total from all causes.

The largest factor in the above is caused by trams and tubs, and amounts to 41·03 of the deaths caused by miscellaneous accidents being 19·72 per cent. above the average of the previous eight years.

The next in importance being on *inclined planes*, and amounting to 25·67 per cent. of the total miscellaneous accidents underground. These are 6·52 lower than the previous eight years.

Explosions of Gunpowder are decreasing, and are 11·76 lower than the average of the previous eight years.

Suffocation by Gases is also decreasing, being 25 per cent. below the average of the previous eight years.

The other items included under the head of miscellaneous accidents, are *Irruptions of Water*, *Falling into Water*, *By Machinery*, and *Sundries*, these are comparatively rare, but are 3·33 per cent. higher than the average of the previous eight years.

Miscellaneous Accidents Underground in Ironstone, etc., Mines;—Amount to 29·16 per cent. of the total, and of this quantity 49½ per cent. are from trams and tubs. This class of accident is, however, 52 per cent. lower during the last year than the average of the previous eight years.

The ratio of persons employed to each death from miscellaneous underground accidents was :—

For 1873–1880	... ...	2,066
1881	... ...	2,637 or 27·63 above the average.

Shaft Accidents.—Coal.

These accidents are decreasing very rapidly, the ratio of persons employed to each death being for the years—

		Percentage.	
		Over First.	Over Last.
1851–1860 = 1,161	... ...	—	—
1861–1870 = 2,121	... ...	82·69	—
1873–1880 = 3,736	... ...	221·80	76·14
1881 = 4,625	... ...	298·36	23·80

The ratio of persons employed to each life lost since the passing of the Mines Regulation Act, 1872, has been as follows, viz. :—

The lowest was in 1873	... ...	3,025
The highest „ 1880	... ...	5,188
The average, 1873–1880	... ...	3,736
And in 1881	... ...	4,625

Being 23·80 per cent. above the average of the previous eight years.

The deaths in shafts are 11·52 per cent. of the total from all causes, and the heaviest item is from falling either from surface or part way down, amounting to 32·68 per cent. of the deaths under this head. They are, however, 21·43 per cent. below the average of the last eight years.

The next item of importance is *By Machinery* whilst descending or ascending, ropes and chains breaking, and by overwinding, amounting to 31·26 per cent. of the deaths in shafts. The deaths caused by overwinding are 60 per cent. below the average of the previous eight years, and by ropes and chains breaking 77·77 per cent. below. The accidents by machinery in shafts are, however, 3·84 per cent. above the average.

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Things falling into shaft either from the surface or part way down are also a source of accident, which is, however, decreasing. They have caused the death of 15¼ per cent. of the total number under the head of shaft accidents, and are 35 per cent. below the average of the last eight years. The miscellaneous accidents in shafts are also below the average, 3·84 per cent.

Shaft Accidents in Ironstone, etc., Mines;—Are 15·27 per cent. of the total, and 16·36 per cent. above the average of the previous eight years.

The ratio of persons employed to each death being—

For 1873–1880	... ...	3,937
And for 1881	... ...	2,966 or 24·72 lower than the average.

Accidents on Surface.—Coal.

The ratio of persons employed to each death was:—

		Percentage.	
		Over or Under First.	Over Last.
For 1851–1860 = 4,872	... ...	—	—
„ 1861–1870 = 4,119	... ...	15·45 under	—
„ 1873–1880 = 5,373	... ...	10·28 over	30·44
In 1881 = 5,485	... ...	12·56 over	2·08

The ratio since the passing of the Mines Regulation Act has been as follows:—

The lowest was in 1876	... ...	4,658
The highest 1879	... ...	6,600
Average 1873–1880	... ...	5,373
And 1881	... ...	5,485

The ratio being 2·08 per cent. above that of the previous eight years.

The deaths under this head are 8·17 per cent. of the total from all causes, and are numerically 3·37 per cent. below the average of the previous eight years.

The deaths by machinery are 18·29 per cent. of the surface accidents, and are 12½ per cent. in excess of the previous eight years.

The deaths from boiler explosions are very few—only two last year against an average of five for the preceding eight years.

Surface Accidents in the Ironstone, etc., Mines;—Are very few, the deaths being one for 5,640 in the eight years 1873–1880, and one in 11,866 in 1881, or 110·39 per cent. better than the previous eight years.

Machinery Underground and Above.

The accidents from machinery, embracing over-winding, breaking of ropes and chains whilst ascending and descending shafts, and boiler explosions, amount to 6·02 per cent., and are 11·96 per cent. below the average of the previous eight years of the total deaths. A part of the accidents on inclined planes ought to be included under this head, but as the Inspectors do not particularise them in their tables it is impracticable to do so.

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TABLE OF TONS OF MINERAL WROUGHT, PERSONS EMPLOYED, FATAL ACCIDENTS, AND LIVES LOST IN THE MINES OF THE UNITED KINGDOM, CLASSED UNDER THE COAL MINES REGULATION ACT, 1872.

YEAR.	TONS OF MINERAL WROUGHT.			NO. OF PERSONS EMPLOYED.			SEPARATE FATAL ACCIDENTS.			NO. OF LIVES LOST.			Death Rate per 1,000 Persons Employed.	* Tons of Coal Wrought per Life Lost.
	Total Coal, Iron, Fireclay, and Shale.	Deduct Iron, Fireclay, and Shale.	* Coal.	Total Coal, Iron, Clay, and Shale.	Deduct Iron, Clay, and Shale.	* Coal.	Total Coal, Iron, Clay, &c.	Deduct Iron, Clay, and Shale.	* Coal.	Total Coal, Iron, &c.	Deduct Iron, Clay, &c.	* Coal.		
1873	143,041,246	11,485,144	131,556,102	514,149	36,154	477,995	973	62	911	1,069	66	1,003	2·098	131.612
1874	140,713,832	8,613,214	132,100,618	538,829	30,876	507,953	895	47	848	1,056	52	1,004	1·984	131.052
1875	147,700,313	9,278,359	138,421,954	535,845	25,693	510,152	927	45	882	1,244	47	1,197	2·346	115.640
1876	148,989,385	10,033,733	138,955,652	514,532	25,432	489,100	839	32	807	933	33	900	1·840	154,395
1877	148,846,260	10,093,964	138,752,296	494,391	24,437	469,954	864	47	817	1,208	47	1,161	2·485	119.820
1878	145,798,138	8,987,583	136,810.555	475,329	21,486	453,843	811	28	783	1.413	28	1,385	3·049	98.851
1879	145,366,369	8,289,961	137,076,408	476,810	21,462	455,348	782	35	747	973	35	938	2·060	146.115
1880	161,466,793	10,364,978	151,101,815	484,933	23,145	461,788	815	39	776	1,318	39	1,279	2·770	118.140
Total...	1,181,922,336	77,146,936	1,104,775,400	4,034,818	208,685	3,826,133	6,906	335	6,571	9,214	347	8,867	2·317	124.594
1881	168,959,931	10,487,926	158,472,005	495,477	23,732	471,745	844	45	799	954	45	909	1·927	174,336
Total...	1,350,882,267	87,634,862	1,263,247,405	4,530,295	232,417	4,297,878	7,750	380	7,370	10,168	392	9,776	2·274	129.219

* Including ironstone, fireclay, and shale tabulated in common with the coal.

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TOTAL NUMBER OF DEATHS FROM ACCIDENTS IN COAL MINES (AND IRON, ETC., MINES WORKED IN COMMON THEREWITH) SINCE THE PASSING OF THE MINES REGULATION ACT, 1872.

CLASS OF ACCIDENT.	Total Number Killed from 1873 to and with 1881.	Proportion which each Class bears to the Whole.	Average Number Killed from 1873 to and with 1880.	Number of Tons of Coal, &c., Produced per Life Lost, 1873-80.	Number Killed during the Year 1881.	Number Killed in 1881 as compared with the previous 8 Years.		Number of Tons of Coal, &c., Produced per Life Lost in 1881.	Tons of Coal, &c., Produced per Life Lost in 1881 as compared with the Average of 1873 to 1880.	
	No.	Per Cent.	No.	Tons.	No.	Above. %	Below. %	Tons.	Above. %	Below. %
Explosions of Fire-damp	2,371	24·25	282	489,488	114	..	59·58	1,390,105	183·99	..
Falls :—										
Falls of side	1,018	10·41	113	1,216,702	110	..	2·65	1,440,655	16·76	..
Falls of roof	2,874	29·40	320	431,890	316	..	1·25	501,493	16·11	..
Total from falls	3,892	39·81	433	318,746	426	..	1·62	372,000	16·71	..
Shafts :—										
Over-winding	71	·45	5	26,304,176	2	..	60·00	79,236,002	201·23	..
Ropes and chains breaking ..	44	·73	9	16,010,948	2	..	77·77	79,236,002	394·88	..
Whilst descending or ascending by machinery	237	2·42	26	5,260,835	27	3·84	..	5,869,333	11·56	..
Falling into shaft from surface ..	127	1·30	15	8,981,914	4	..	73·33	39,618,001	341·08	..
Things falling from surface ..	57	·58	7	21,245,681	5	..	28·57	31,694,401	49·18	..
Falling from part way down ..	241	2·46	27	5,211,205	29	7·41	..	5,464,552	4·86	..
Things falling from part way down	115	1·18	13	10,325,004	8	..	38·46	19,809,001	91·85	..
Miscellaneous	234	2·40	26	5,286,007	25	..	3·84	6,338,880	19·92	..
Total in shafts	1,126	11·52	128	1,078,882	102	..	20·31	1,553,647	44·00	..
Miscellaneous Underground :—										
Explosions of gunpowder, etc. ..	151	1·54	17	8,123,348	15	..	11·76	10,564,800	30·05	..
Suffocation by gases	106	1·08	12	11,389,437	9	..	25·00	17,608,000	54·60	..
Irruptions of water	35	0·36	4	31,565,011	..	..	400·00	..	..	..
Falling into water	6	·06	1	184,129,267	..	..	100·00	..	..	..
On inclined planes	408	4·17	46	3,026,782	43	..	6·52	3,685,395	21·76	..
By trams and tubs	652	6·67	71	1,941,609	83	19·72	..	1,909,301	..	1·66
By machinery	48	·49	5	27,619,385	8	37·50	..	19,809,001	..	28·27
Sundries	183	1·87	20	6,904,846	23	15·00	..	6,890,087	..	0·21
Total miscellaneous underground	1,589	16·25	176	784,641	181	2·84	..	875,535	11·58	..
Surface :—										
By machinery	146	1·50	16	8,631,058	18	12·50	..	8,804,000	2·00	..
Boilers bursting	43	·44	5	26,945,741	2	..	60·00	79,236,002	194·09	..
Miscellaneous	609	6·23	68	2,034,577	66	..	2·94	2,401,091	18·01	..
Total on surface	798	8·17	89	1,551,651	86	..	3·37	1,842,700	18·75	..
Gross total	9,776	100·00	1,108	124,594	909	..	17·96	174,336	39·92	..

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Summary of Deaths Caused by Accidents in and about Mines Classed under the Coal Mines Regulation Act, 1872, Distinguishing those which occurred in Coal Mines (and Iron, etc., Mines Worked in Common therewith) from Mines in which Iron, Clay, and Shale is Worked Separately.

Year.	Gas.	Falls.						In Shafts.																		Miscellaneous Underground.																Surface.						Total.	
	Explosions of Fire-damp.	Falls of Side.		Falls of Roof.		Total from Falls.		Over-winding.		Ropes and Chains Breaking.		By Machinery whilst Ascending or Descending.		Falling into Shaft from Surface.		Things Falling from Surface.		Falling from Part Way Down.		Things Falling from Part Way Down.		Miscellaneous in Shafts.		Total in Shafts.		Explosions of Gunpowder.		Suffocation by Gas.		Irruptions of Water		Falling into Water.		On Inclined Plane.		By Trams and Tubs.		By Machinery Underground.		Sundries.		Total Miscellaneous Underground.		By Machinery.		Boilers Bursting.		Miscellaneous.		Total.		Gross Total.	
	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.	Coal.	Iron, &c.
1873	100 ..	121	2	340	28	461	30	4	1	15	..	38	2	24	3	8	1	34	3	8	1	29	2	158	13	26	4	9	..	3	..	2	..	51	1	79	10	9	1	23	3	202	19	14	1	5	..	63	3	82	4	1003	66
1874	166 ..	106	8	288	11	394	19	6	1	11	..	34	1	18	..	4	..	41	4	8	2	22	2	144	10	28	3	18	..	2	..	1	..	45	..	88	6	4	..	16	3	202	12	22	2	9	3	67	6	98	11	1104	52
1875	288 ..	116	11	321	10	437	21	2	2	6	..	38	3	18	..	13	..	32	1	20	3	33	1	162	10	21	1	32	..	8	..	..	..	37	1	79	9	9	..	27	3	213	14	16	..	2	1	79	1	97	2	1197	47
1876	94	116	6	320	7	436	13	3	..	3	..	19	1	18	1	9	1	19	4	20	..	31	..	122	7	15	2	3	..	2	..	..	..	49	2	61	..	1	..	12	2	143	6	22	2	8	..	75	4	105	6	900	33
1877	341 4	126	9	304	9	430	18	4	..	4	..	18	3	15	..	4	1	31		20	..	28	1	124	5	14	..	15	..	9	..	..	..	40	3	69	9	7	2	19	..	173	14	15	2	6	..	72	4	93	6	1161	47
1878	586 ..	112	6	345	6	457	12	14	..	4	..	26	..	13	..	3	..	8	1	20	1	21	..	109	2	12	1	7	2	10	..	1	..	39	3	51	3	3	..	26	3	149	12	13	..	4	..	67	2	84	2	1385	28
1879	184 ..	110	5	296	15	406	20	7	..	17	..	16	.	11	..	6	..	31	2	5	..	23	2	116	4	12	1	10	1	1	..	1	..	54	1	70	6	3	.	12	..	163	9	16	..			50	1	69	2	938	35
1880	498 1	101	5	344	12	445	17	2	..	9	..	21	..	6	..	5	..	16	1	6	..	24	1	89	2	8	6	3	..	..	..	1	..	50	1	72	7	4	..	25	1	163	15	10	1	4	..	70	3	84	4	1279	39
Total..	2257 6	906	52	2558	98	3466	150	42	4	69	..	210	10	123	4	52	3	212	16	107	7	209	9	1024	53	136	18	97	3	35	..	6		365	12	569	20	40	3	160	15	1408	101	128	8	41	5	543	24	712	37	8867	347
1881	114 2	110	4	316	20	426	24	2	3	2	..	27	..	4	1	5	1	29	1	8	..	25	2	102	8	15	2	9	1	..	..	..	..	43	2	83	3	8	..	23	1	181	9	18	..	2	..	66	2	86	2	909	45
Total..	2371 8	1018	56	2874	118	3892	174	44	7	71	..	237	10	127	5	57	4	241	17	115	7	234	11	1126	61	151	20	106	4	35	..	6	..	408	14	652	53	48	3	183	16	1589	110	146	8	43	5	609	26	798	39	9776	392

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PRODUCTION OF COAL IN THE UNITED KINGDOM.

Extract from the Report of the Commissioners appointed to inquire into the several matters relating to coal in the United Kingdom in 1871, Vol. 3, folio 32:—

The Durham and Northumberland coal-field for a long period appears, as nearly as can be ascertained from the imperfect returns which exist, to have produced about a quarter of the coal yielded by the United Kingdom.

In 1778 the vends of the Northern ports were considerably less than two million tons. Therefore, regarding the above proportion as being nearly correct, the production of this island at that time would not reach seven million tons.

With a full appreciation of the uncertainty of this kind of computation the following may be considered an approximate estimate of the production of the kingdom in the earlier years of the last century:—

Years.	Vend of Northern Ports.	Estimated Produce of Kingdom.
1660	537,000	2,148,000
1700	653,000	2,612,000
1750	1,193,457	4,773,828
1770	1,551,350	6,205,400
1780	1,606,244	6,424,976

The constancy of the proportion existing between the coal imported into London and the vends of the Northern ports for the years given, enable the quantities for other years, for which no returns are available, to be computed without much fear of error. Thus the following quantities are obtained as an approximation to the coal produced in the United Kingdom in the years given:—

1785	6,888,712
1790	7,618,760
1795	10,681,728
1800	10,080,300
1816	27,020,115

Folio 61.—Even so recently as from 1850 to 1854 the most uncertain estimates respecting the quantities of coal raised were prevalent. The quantity of seaborne coal was of course known from the returns regularly published by order of the House of Commons, but very little information was to be obtained respecting the inland traffic in coal, excepting such as was brought to London. Consequently those who wrote on the subject were obliged to satisfy themselves with the loose statements obtainable from various uncertain sources. The results given for those years are consequently not strictly reliable.

The following are, however, the estimates usually given. J. R. McCulloch, Commercial Dictionary:—

	Tons.
1839	31,024,417
1845	34,600,000
1855	58,200,000

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Mr. Joseph Dickinson in his Report, 1853, estimates the output of the Kingdom at 54,000,000.

The Committee, after enumerating several authorities and returns, state that:—

From these and several other direct and collateral sources of information, we believe the average production of coal in each of the three years—1851, 1852, 1853, may be taken as follows:—50,875,000.

PRODUCTION OF COAL IN THE UNITED KINGDOM FROM THE YEARS 1854 TO 1880.

Year.	From 1854 to 1869, taken from the Report of the Commissioners appointed to inquire into the several matters relating to Coal in the United Kingdom (see Appendix 62, Vol. III. of Report, 1871). Tons.	From 1856 to 1871, taken from the Report of the Select Committee on Coal, from a Paper handed in by Mr. Meade (see Appendix No. 3 of Report on Coal, 1873). Tons.
1854	64,661,401	—
1855	64.453,070	—
1856	66,645,450	71,787,552
1857	65,394,707	74,611,941
1858	65,C08,649	73,725,895
1859	71,979,765	78,278,957
1860	84,042,698	82,662,702
1861	86,039,214	90,705,796
1862	81,638,338	90,989,666
1863	86,292,215	92,819,855
1864	92,787,873	95,122,419
1865	98,150,587	98.911,169
1866	101,630,544	100,728,881
1867	104,500,480	105,077,743
1868	103,141,157	104,566,959
1869	107,427,557	108,003,482
1870	*110,431,192	112,875,725
1871	117,352.028	117,439,251
1872	123,497,316	†123,393.853
1873	127,016,747	128,680,131
1874	125,043,257	126,590,018
1875	131,867,105	133,306,485
1876	133,344.766	134,125,166
1877	134,610,763	132,179,968
1878	132,607,866	132,612,063
1879	134,008,228	133,720,393
1880	146,818,622	146,969,409

* In the first column, from 1870, the quantities are taken from Hunt's Mineral Statistics.

† In the second column, from 1872, the quantities are taken from the Mines Inspectors' Reports.

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ABSTRACTS FROM THE MINES INSPECTORS' REPORTS FOR THE YEAR 1881.

NOTE.—The marginal numbers refer to pages of the Report, and when the personal pronoun is met it refers to the Inspector of the District.

Mr. DICKINSON'S report (North and East Lancashire and Ireland). The greatest depth sunk to in this district is 2,820 feet, at Ashton Moss Colliery. The longest air current is at the Bradford Colliery, which is over eight miles. 4. Depth of deepest pit.

The Bridgewater group of collieries have 207 miles of underground passages, which include forty miles of boat levels not at present in use and six miles in use. Length of air current and underground passages.

The deepest rock-salt mine is near Carrickfergus, in Ireland. It is 900 feet in depth, and the excavation forty feet in height, with the roof supported on pillars of natural salt. 5. Deepest rock salt mines.

The greatest area excavated in any of the rock-salt mines is at Marston, in Cheshire, where the area of the chamber is about forty acres and the height about sixteen feet, with the roof supported upon pillars of natural rock salt.

Mr. Dickinson's report includes abstracts from mining reports of Victoria, New Zealand, and France and Algeria, as well as a short review of the reports on fire-damp mines in Belgium, Germany, and England, by MM. Pernolet and Aguillon. 5, 6, & 7. Abstracts of foreign reports.

Mr. Dickinson's report on the Salt Districts consists of eleven parts, and deals with the geological features of the district, the mines, production, landslips, the bill, cause of damage, as to public policy of tax, and summary. The report occupies sixty-seven pages, and is replete with sections, plans, and methods of working, including an historical sketch of salt mining. 52. Salt district report. 117.

Mr. WYNNE'S report (North Staffordshire, Cheshire, and Shropshire). Explosions of fire-damp have been four in number, causing thirty-eight deaths, all of which could have been prevented with ordinary care and caution. 119. Explosions.

The Whitfield explosion caused the death of twenty-five persons. Mr. Wynne reports that the explosion originated from the firing of soot in a flue coming from a smithy forge underground, and which set fire to gas near the upcast pit. The manager, Mr. E. Thompson, sen., was committed to take his trial at Stafford before Mr. Justice Cave; he was, however, acquitted, the evidence not being sufficient to warrant a conviction. Whitfield explosion. Trial of manager

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122. Lillydale explosion. The Lillydale explosion was caused by driving against an accumulation of water without due foresight and liberating water which drove gas from a goaf on to naked lights, which exploded, causing the death of eight persons. The manager, Mr. Enoch Perrins, was brought to trial, but was acquitted.

Trial of manager.

130 Skelton explosion. The Shelton colliery explosion, causing the death of four lives, was brought about by the dangerous custom of having furnaces underground fed with return air. Negligence was attributable to all the parties concerned, from the manager to the humblest person in the pit.

Negligence.

135. Accidents from falls of roof and sides. It may be safely calculated that the deaths from this cause will be still further reduced in number when the use of powder in the thick and fiery mines is entirely abandoned, for it is found that in those mines where powder is not used scarcely a life has been lost from falls of roof.

136. Falls of roof and powder.

137.

151. Falls of roof and timber. Mr. ALEXANDER'S report (Western District of Scotland). Falls of roof, as hitherto, continue to form a large proportion of the accidents in this district, and amount to 58 per cent. To a considerable extent such accidents are inseparable from underground work. As exhaustion progresses a thorough system of support should be given to the roof. At present the theory is to delay putting in support until the roof shows symptoms of weakness. All roofs should be supported whether strong or not, for a wooden support, such as a prop, has often the effect of attracting attention to insecurity or imminent danger.

154. Attention to report books. The report books are best attended to in those works where the manager occasionally appends his initials to them. Many officials still append the X to their reports.

No. of managers. A liberal addition is always being made to the list of managers of mines; at present the supply is quite equal to the demand. It is the opinion of some owners that there is a falling off in the class of managers in so far that they are less practical than formerly. It should be remembered, however, that previous to the time when certificates were granted under-managers were selected in a great measure for their practical qualifications and tact in the management of men. Thirty-nine candidates presented themselves at the late examination.

Managers not so practical.

Reason.

Candidates at last examination.

No. of Candidates.	Practical men, such as Overmen, Firemen, etc.	Persons generally Engaged about Mines.	Persons Educated with a view of becoming Mining Engineers.
39 ...	29 ...	4 ...	6
Number passed	10 ...	1 ...	4

70. Managers praised. Mr. EVANS' report (Derby, Nottingham, Leicester, and Warwick). It is my satisfaction and pleasure to record my testimony to the fact that the class of gentlemen now employed as resident managers of the mines are doing their part in improving the machinery, the ventilation, and general arrangements for the security of the mines and the safety and well-being of the workmen.

172 Insecurity of Davy-lamp. In my opinion the ordinary Davy-lamp is not such a one as ought to be entrusted to workmen to be used in a fiery colliery, for it is only safe in very slow velocities, and when used with the greatest care.

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173. Falls of roof and timber with supervision.

Falls of roof and sides caused 50 per cent. of the total number of deaths. The system adopted in this district is that the stallman is responsible for the proper supervision and security of the roof and sides, and it is his duty in all cases to use a sufficient quantity of timber to make the places to the best of his judgment secure and safe; but I regret to say that, probably on account of the familiarity with exposure to danger, he is not so careful as he might be.

Shaft accidents, small.

Shaft accidents are reduced almost to a minimum considering the enormous quantity of coal raised and the great number of persons passing through the shafts, and this to a great extent must be attributed to the marked improvement in the machinery and general discipline of the collieries.

178. Magistrates won't assist.

Stipendiary magistrates.

Calls attention to the great difficulty in obtaining convictions of cases by magistrates. The magistrates are often intimately connected with the mines and will not attend or they dismiss the cases against evidence. It is to be regretted that stipendiary magistrates cannot hear important mining cases.

179. Gunpowder.

Gunpowder ought not to be used in collieries said to give off such quantities of gas that cannot be diluted by an ordinary amount of ventilation, but in the mines of the Midland district, worked under the well-known long-wall system, with ample ventilation, with goafs properly filled with *débris* so that there is no room left for gas to accumulate, powder at the discretion of the manager may be used, but never until after the working places and those contiguous thereto have been properly examined by a competent person and found to be free from gas.

Gunpowder arbitration and unnecessary responsibility of inspectors.

If the Chief Inspector of the district considers that the use of powder is attended with unnecessary danger he may give the owners notice and proceed to arbitration, and until he has tested the Act of Parliament in this respect I consider the inspector incurs great and unnecessary responsibility.

180. Lime process.

Messrs. Smith and Moore's improved apparatus for breaking down or getting coal by caustic lime appears to be deserving of further attention and consideration.

182. General rule 8, "persons ordinarily employed"

Opinion of counsel.

With regard to the General Rule 8 of the Coal Mines Regulation Act, 1872, the Government issued a circular in which the Attorney and Solicitor-general state that "persons ordinarily employed in the mine" would include the night shift, consisting of labourers engaged in making ready the mine for the mining operations of the miners constituting the day shift. They think the distinction intended to be drawn is between those ordinarily employed in the mine, in whatever capacity, and those specially employed in the blasting operations.

Simons' observations.

The observations by Mr. Simons on General Rule 8 are appended.

183. Coal dust (Chesterfield Institute).

The coal dust experiments conducted by a committee of the Chesterfield and Derbyshire Institute of Mining, Civil, and Mechanical Engineers, may be taken to show generally that the purer the atmosphere of the mine the greater the amount of dust required to make it inflammable; and conversely with regard to dust in air containing fire-damp. Also that in no mine in its normal state, with the ventilation free from fire-damp, would an ordinary blown-out shot raise sufficient dust to make the ventilating current an inflammable mixture, such as would ignite from the same shot flame, and create what might be termed, but really would not be, an

Dust alone won't cause explosion.

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explosion; the great quantity of dust required for such a current of air to become inflammable being such as to render the current an intensely black cloud surcharged with dust.

185. "Daily supervision."

"Daily supervision" (in Section 26 of the Mines Act), in the opinion of counsel of the highest standing, does not mean inspection; if it did it would be physically impossible to manage a mine so as to comply with that interpretation of the law.

187. Managers now more practical and better educated. System of examination good.

The class of men now seeking to obtain certificates possess higher educational qualifications as well as practical experience. I quite agree with the opinion expressed by the members of this Board that it is most desirable to continue the present system, which has worked so well, in preference to the centralization system recommended by a few.

188. List of managers.

List of certificated managers, acting and having obtained certificates, in the Midland district, giving number of certificate, date, whether of service or competency, and where acting, is appended.

203. List of abandoned mines.

List of abandoned mines, showing name of owner, name of mine, where situated, name of seam, and date of abandonment.

208. Table showing names of collieries and lives lost.

Table showing total number of deaths in the named individual collieries during the years 1865 to 1881.

239. Number killed and disabled.

Mr. BAKER'S report (South Staffordshire and Worcestershire Districts). Whilst only forty-one persons have lost their lives, 300 have been more or less disabled—nine permanently.

240. Prosecutions.

There were eleven persons against whom proceedings were instituted for violations of the law—four were withdrawn on payment of costs, and included two managers, one owner, and a chartermaster; the rest, who were all managers or owners, with the exception of an overman, were fined. Section 39 of the Act was violated in three cases; and in others Sections 12, 13, 14, 47, and 57: General Rules 1, 2, 3, 20, 24, and 29, and Special Rules 24 and 28 (in two cases).

241. Compressed air experiments and blasting.

Experiments are being made by myself and Major Majendie with compressed air and blasting tools at the Royal Arsenal.

241. "Bump" as source of an explosion.

An explosion occurred at Eight-Locks Colliery, caused by a "bump" which, from time immemorial, has been a fruitful source of mining fatalities through falls of coal in the 10-yard seam and occasionally in the thinner seams. It acts as an upheaval, and in the present instance raised the floor some four or five feet for a distance of from fifteen to twenty yards, knocking out all the timber. One person was killed.

242. Falls.

Only seventeen cases of deaths by falls took place.

243. Rope breaking, not being kept properly.

Two accidents in shafts took place from the breaking of ropes, one on a capstan and the other on a jack, caused by the ropes being kept in unsuitable places.

243. Indicator gone wrong.

Through an indicator going wrong one person was killed by overwinding.

258. Small increase of men and great increase of output.

Mr. MOORE'S report (Eastern District of Scotland). With an increase of only 3·4 per cent. in the number of persons employed in the preceding year, 16 per cent. more coal was raised, while in the United Kingdom the increase in output amounted to 5 per cent. In Lanarkshire the excess in

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output was 22 per cent., with an increase of only 3 per cent. of men. This resulted from two causes. In the first place, the workmen have never in my experience been better employed or worked more steadily and contentedly; and, in the next place, the quantities raised by the new collieries in the Hamilton district are still increasing, and as these collieries are for the most part working solely the Ell coal, which is about seven feet thick and easily worked, a miner puts out a much larger quantity than in a thin seam.

Two persons were killed and forty-three persons injured by explosions of fire-damp, all of which might have been avoided had proper precautions been taken. — Explosions avoidable.

The output of the district was fourteen million tons, equal quantities being worked by long-wall and stoop and room. — 260. System of working.

3,551 safety-lamps were used, of which 1,494 were gauze lamps, 828 Davy, 411 Protector, 394 Clanny, 240 Jack, 160 Williamson, and 24 Mueseler lamps. — 258. Lamps.

An estimated quantity of 516 tons of gunpowder were used—285 in collieries worked by long-wall and 231 tons by stoop and room. — 259. Gunpowder, quantity used.

Swan's Electric Light is in use at the Earnock Colliery at the bottom of the shaft, to the extent of eighteen lamps. An attempt to carry it in 800 yards was abandoned. Sees no reason yet for doubting that it will be more extensively used. — 259. Electric light.

Timber should be used whatever be the apparent state of the roof. (See Mr. Alexander's report.) — 259. Falls and timber.

The long-wall system of working caused twenty out of thirty-one deaths by falls, six being falls of roof in roads, six at face, and five by falls of "brushing" at face. — 259. Long-wall and falls.

Haulage machinery increases the number of deaths on incline planes and by trains. — 260. Haulage and deaths.

There were four prosecutions, three of which resulted in fines and one in imprisonment. — 261. Prosecutions.

Table showing wages earned by a first-class collier at a Wishaw colliery. He worked 300 days, and earned a net wage of £69 15s. 0½d. — 274. Wages.

Ditto of an average collier who worked 266 days and earned £51 6s. 4d. — 275. Wages.

Table of coal mines, with the mode of working, ventilation, size and depth of shaft, number of splits, length of airways, number of safety-lamps, etc. — 278. Table of mines with interesting data.

Mr. WALES' report (South Wales District). Deaths from falls of stone and coal will always be large owing to the roofs being bad. The cost of timber used per ton of coal ranges from 6d. to 1s. — 319. Falls and bad roof.

Thinks that if persons were specially appointed to set the timber these accidents would diminish. — Falls and deputies.

Six persons were proceeded against for violation of the Act, all resulting in fines with the exception of one person; three were managers, and the rest overmen and firemen. — 321. Prosecutions.

Shot firing in the working of the fiery seams should not be resorted to. In making height—only in cases where pure air traverses the district. — 322. Gunpowder and fiery seams.

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323. "Vacuum theory." Thinks that shots cause explosions, especially blown-out shots, not by igniting accumulations of gas but from causing a vacuum, which draws a large quantity of gas together which then becomes ignited.

341. Falls. Mr. WARDELL'S report (Yorkshire and Lincolnshire District). Falls of roof cause 53 per cent. of the total loss of life.

349.—Abandoned mines. List of abandoned mines.

356. Stephenson lamp safe, Davy and Clanny lamps condemned. The Stephenson lamp appears to be one of the safest lamps. The use of unprotected Davy and Clanny lamps in an explosive mixture where the current exceeds six feet a second is attended with risk of accident almost amounting to certainty.

Gunpowder and lamps. The concurrent use of gunpowder and safety-lamps should gradually cease.

357.—Lamps and gas testing. Safety-lamps should always be tested by means of gas.

Watering roads sometimes undesirable. Watering the roads to keep down dust would probably in some mines not be advisable, for upheaval of the floor might take place and spontaneous combustion be promoted.

357. Falls and timber. With regard to falls, a sufficient staff of deputies should be provided and an ample stock of timber should be ready for use and within easy access of the men.

358. Prosecutions. Proceedings were instituted against certain owners and managers which in each case resulted in fines.

384. Explosions and naked lights. Mr. WILLIS'S report (North Durham, Northumberland, Cumberland, and detached part of North Lancashire). There were five explosions of gas, causing injury to eight persons, all occurring in pits where naked lights are used.

386. Falls. Deaths by falls constitute 51½ per cent. of the total number of deaths.

407. Dr. C. LE NEVE FORSTER'S report (Metalliferous Mines in Anglesey, Brecon, Cardigan, Carnarvon, Denbigh, Flint, Merioneth, Montgomery, Radnor, Shropshire, and Isle of Man).

426. Blasting gelatine explosion. A serious explosion occurred at the Minerva Mine through the using of blasting gelatine, caused by a candle falling on the explosive, killing five men. Negligence in not obeying strict instructions caused this accident.

429. Slate mines dangerous. Slate mines are twice as dangerous as the true metal mines, the death-rate being 3·28 per 1,000 employed underground during seven years. Visited other slate mines abroad at own expense to study their mode of working in order to discover if anything could be done to save life in Welsh slate mines.

French slate mines not so dangerous. Slate mines in Ardennes (France) most resemble the Welsh mines, but their mode of working is very different from that employed in this country. The pillars are left along the line of strike, and the great peculiarity is that none of the large open cavities are allowed to remain. All the chambers are filled with rubbish as fast as they are excavated, so that the men stand upon rubbish while at work instead of being supported by chains or ladders as the Welsh miners. The death-rate per 1,000 persons employed underground is 2·85 for eleven years in the Ardennes.

432. Prosecutions. There were seventeen prosecutions against managers and mine-owners for violation of the Act. Two were dismissed on payment of costs, and in one case the summons was withdrawn. The rest all resulted in fines.

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Mr. BELL'S report (South Durham, Westmoreland. and the West Riding of Yorkshire). 456.

Mining accidents are increasing. 456.

Accidents taken with Great Britain generally compare very favourably, for there are 577 persons employed per life lost in this district against 519 in the whole kingdom; also, 259.629 tons of mineral raised per death compared with 177,106 in the United Kingdom. (This includes the Cleveland district.) 458. Accidents compared.

There is a decrease of three tons of coal per man raised per annum compared with last year, being 398 against 401; the total for the Kingdom is 340. 462. Tons raised per man decreasing.

In coal mines 20½ per cent. of the men employed are employed aboveground, while in ironstone mines 16¾ per cent. are employed aboveground.

The Fleuss Breathing Apparatus and Lamp were found to be of the greatest possible value in enabling the explorers to ascertain the state of the mine in the Maudlin Seam at Seaham on its being reopened. I consider them to be very valuable in cases of fire or outbursts of gas, or even irruptions of water, and would be glad to see them kept ready for use at every colliery; they are light, portable, and easily managed. (Here follows a description of the apparatus.) 463. Fleuss apparatus good, should be kept at every colliery.

The loss of life from falls amounts to 40 per cent. in Durham and 54 per cent. in Cleveland of the total accidents. Accidents on inclines and engine planes and by machinery are increasing, amounting to 29½ per cent. in Durham and 12½ per cent. in Cleveland. 467. Falls and haulage and deaths.

No person should be allowed to travel on incline roads under any pretext while sets are being run. Travelling on incline roads should be stopped.

Six mines have been abandoned during the year—four collieries and two ironstone mines. 470. Abandoned mines.

A short Act. 44 and 45 Vic., ch. 26, Stratified Ironstone Mines (Gunpowder) Act, 1881, has been passed with regard to the exemption of the General Rule 8 of the Coal Mines Act, 1872. Gunpowder Act, 1881.

I have again felt it unnecessary to take legal proceedings against any of the owners or managers of the mines during the past year; the provisions of both Acts have been fairly well observed, and whenever I have come across anything that might appear to be wrong I have experienced no difficulty in getting it at once remedied. 471. No Prosecutions. Managers willing.

Mr. HALL'S report (West Lancashire and North Wales). The death-rate higher than in 1880 owing to the Abram Explosion causing death of forty-eight persons. 497. High death-rate owing to Abram explosion.

A decrease of output of 197,543 tons on previous year, the quantity raised being 11,933,570 tons. This was owing to a strike of from seven to eight weeks duration. Output decreased by strike.

During the year, 262 men were employed and 79,030 tons raised per life lost.

Fatal accidents in North Wales continue very frequent, and to endeavour to secure some improvement the Assistant-Inspector has removed from Liverpool to Chester. 498. Accidents in North Wales frequent, sub-inspector removed to North Wales.

There were seven explosions in Lancashire, causing the death of fifty-three 499. Explosions.

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persons; two were caused by open lights, three were caused by blasting with gunpowder, and two formed inquiries for reports (one of these was caused by neglecting to examine the workings immediately before firing a shot, the other case was the Abram explosion—reason given below). There were three explosions in North Wales, causing the death of two persons; two were caused by open lights and one was the subject of a report.

508. Abram explosion caused by Davy lamp.

The Abram explosion was caused by a Davy lamp in a rapid current of explosive mixture.

510. Extincteurs valuable.

I wish to point out the great value of portable fire extincteurs in exploring a mine after an explosion. The explosion has had the effect of causing the owner to introduce some more perfect lamp in place of the Davy then in use.

553. Furnace and return air caused explosion.

In the explosion in North Wales at the Llay Hall Colliery, feeding the furnace with return air was the cause. It is an ancient method of ventilating mines which dies a hard death—a death so slow that one is compelled to believe that many colliery managers cannot be taught except by disastrous personal experience.

556. Falls and responsibility of managers.

The rule regarding the security of the roof and sides of all travelling roads and working places leaves the responsibility with the manager of the mine, and he fails in his duty to his workpeople if he is not careful that this supervision is effectively carried out by his officials.

557. Prosecutions.

Three actions were brought against three owners, of which only one resulted in a fine.

558. Employers' Liability Act.

The powers of the Employers' Liability Act have not been resorted to, and a mutual arrangement exists through the medium of the Lancashire and Cheshire Permanent Relief Society, the owners having increased their annual subscription 10 per cent., making their total subscription one quarter of the funds on the workmen agreeing to forego any claim to damages.

557. Attendance of magistrates difficult.

A difficulty exists in obtaining attendance of magistrates as non-mine-owners in actions against men by the managers.

558. Gunpowder and men out of pit.

Blasting should only be allowed when the whole of the ordinary workpeople are out of the mine. This is generally done in the dangerous Wigan 9-foot seam.

558. 2 per cent. of fire-damp and coal dust.

It has been proved that 2 or 3 per cent. of fire-damp does, on having fine coal dust mixed with it, become at once a most inflammable mixture.

Copper stemmers dangerous, wooden ones preferred.

Copper stemmers have proved to be dangerous; the remedy lies in using wooden ones.

Copies of report should be sent to managers. Government refuses to do this.

From year to year I have applied that copies of the local Inspector's report should be sent to each manager, for by thus bringing the circumstances and causes of the various accidents which occur during the year under their notice precautionary measures might suggest themselves and result in a saving of life, but this application has always been refused.

560. Prosecutions.

List of prosecutions against workmen for breaches of the Act. There were seventy-two cases; in twelve of these the defendant either absconded or failed to appear, and the rest resulted in fines and in two cases imprisonment in default of paying fines.

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608.
609. Falls and care and timber.

Mr. CADMAN'S report (Devon, Dorset, Gloucester, Monmouth, Somerset, and portions of Brecon and Glamorgan). Falls of roof and sides will, notwithstanding every precaution, prove a prolific source of accident, and I wish to impress very strongly both upon masters and men the necessity for exercising the greatest possible care in securing and timbering the working places. It is not unfrequent that men will rather run the risk of working in a dangerous place than spare the short time required to put up a prop or pull the coal down. Spraggs should be used when holing.

610. Carbonic oxide gas killing four people.

Four men were killed by carbonic oxide gas while waiting underground for the steam in a boiler to gain sufficient pressure to work a pump at the Holly Bush Colliery in Monmouthshire. It seems that the night had been stormy and that wind must have forced the products of combustion to accumulate in the drift or to pass back out of the furnace doors. Steam is now conveyed from bank. Lights burned in the gas.

611. Falls.

Out of sixty-eight deaths in the district nine were occasioned by explosions and forty-one by falls, or 60·3 per cent.

Arbitration as to lamps.

Arbitration has been resorted to by the Government and the owners of a South Wales colliery near Abertillery as to the compulsion of using safety-lamps. Mr. W. T. Lewis is arbitrator on behalf of the Government, Mr. T. Forster Brown on behalf of the Company, and Mr. G. B. Forster is umpire.

630. Prosecutions.

Three prosecutions were instituted, all of them resulting in fines.

632.
633. Out-put of black tin decreasing.

Mr. FRECHEVILLES report (Metalliferous Mines in Cornwall, Devonshire, Dorsetshire, and part of Somersetshire). The production of black tin has gradually decreased since 1878.

634.

679 persons are employed per death, which is equal to 1·47 per 1,000.

656. Prosecutions.

Prosecutions were instituted against two managers; one case was dismissed on technical grounds, the other resulted in a fine.

657. Employers' Liability Act.

An action was brought under the Employers' Liability Act by a father for the death of his son, and he was awarded £100 without costs, being the amount which he claimed.

658. Liability Assurance.

A large number of the mine owners have insured against accidents in the Employers' Liability Assurance Corporation, Limited. The present rate is 5s. per £100 per annum paid in wages to cover all risks under the Act of 1880, and 12s. 6d. per £100 for all accidents.

658. Nobel's patent expired—cheap dynamite.

Nobel's patent having expired dynamite has fallen in price from 2s. to 1s. 7½d. per lb.

Travelling by ladders and machines.

There are seven man-engines and eight cages or "gigs." In using ladders one man was killed; in using man-engines one man was injured; and in using cages three men were killed and one injured.

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QUANTITY OF MINERAL RAISED UNDER THE COAL MINES REGULATION ACT OF 1872, PERSONS EMPLOYED, DEATHS, NUMBER OF PERSONS EMPLOYED PER DEATH AND MINERAL RAISED PER DEATH, AND QUANTITY OF MINERAL RAISED PER MAN PER ANNUM DURING THE YEAR 1881 IN THE DIFFERENT MINING DISTRICTS OF THE UNITED KINGDOM.

INSPECTORS' DISTRICTS.	Output.	No. of Persons Employed.	Deaths by Accident.	Persons Employed per Life Lost.	Tons raised per Life Lost.	Tons raised per Man per Ann.	Death Rate per 1,000.
Mr. James Willis—							
Cumberland, Durham (N.), and Northumberland	(4) 16,169,811	(5) 47,396	(9) 64	(3) 740	(3) 252,653	(5) 341	(3) 1·35
Mr. Thomas Bell—							
South Durham and Westmorland	21,818,054	54,825	85	645	256,683	398	1·55
North Riding of Yorkshire and Cleveland	6,481,500	8,122	24	338	270,062	796	2·96
Total	(1) 28,299,554	(1) 62,947	(3) 109	(7) 577	(1) 259,629	(1) 449	(7) 1·73
Mr. Dickinson—							
North and East Lancashire ..	9,432,548	31,673	47	674	200,692	298	1·48
Ireland	131,335	1,070	4	267	32,834	122	3·74
Total	(9) 9,563,883	(8) 32,743	(10) 51	(4) 642	(8) 187,527	(11) 292	(4) 1·56
Mr. Hall—							
North Wales & West Lancashire.	(7) 11,933,570	(7) 39,630	(1) 151	(12) 262	(12) 79,030	(10) 301	(12) 3·81
Mr. Wardell—							
Yorkshire	18,703,242	60,531	75	807	249,376	309	1·23
Lincolnshire (ironstone)	90,589	113	..	..	..	801	..
Total	(2) 18,793,831	(2) 60,644	(5) 75	(1) 808	(4) 250,584	(8) 309	(1) 1·23
Mr. Evans—							
Derbyshire, Leicestershire, Nottinghamshire, & Warwickshire.	(6) 15,657,148	(4) 49,979	(8) 64	(2) 781	(5) 244,643	(7) 313	(2) 1·28
Mr. Wynne—							
North Staffordshire, Cheshire, and Shropshire	(11) 8,644,382	(11) 24,499	(4) 77	(11) 318	(11) 112,264	(4) 352	(11) 3·14
Mr. Baker—							
South Staffordshire & Worcestershire	(8) 10,421,683	(12) 23,806	(12) 41	(5) 581	(2) 254,187	(2) 437	(5) 1·72
Mr. Cadman—							
Monmouthshire, Somersetshire, and part of Glamorganshire ..	(12) 8,475,896	(9) 31,044	(7) 68	(9) 456	(9) 122,335	(12) 273	(9) 2·19
Mr. Wales—South Wales.. ..	(3) 16,261,281	(3) 53,452	(2) 133	(10) 402	(10) 122,265	(9) 304	(10) 2·48
Mr. Moore—East Scotland	(5) 15,946,102	(6) 42,721	(6) 75	(8) 569	(6) 212,614	(3) 373	(8) 1·75
Mr. Alexander—West Scotland ..	(10) 8,792,790	(10) 26,616	(11) 46	(6) 578	(7) 191,147	(6) 330	(6) 1·72
Total and average for Kingdom ..	168,959,931	495,477	954	519	177,106	341	1·92
Of which was coal	154,184,300	..	..	..	..	..	..

COMPARISON OF THE DIFFERENT DISTRICTS OF THE INSPECTORS.

Output.—Mr. Bell here stands first, being nearly ten millions above Mr. Wardell, who is second, who is again two millions above Mr. Wales, who is third, Mr. Willis being fourth; Mr. Moore and Mr. Evans follow close by, being fifth and sixth. Then come Mr. Hall, Mr. Baker, and Mr. Dickinson as seventh, eighth, and ninth respectively; and then, those of eight million tons and over, Mr. Alexander tenth, Mr. Wynne eleventh, and Mr. Cadman the last, being nearly twenty millions behind Mr. Bell.

Persons Employed.—Here again Mr. Bell is first, but the difference between him and Mr. Wardell, who is second, is not so great as the proportional difference of output; then Mr. Wales as third and Mr. Evans as fourth; and then only Mr. Willis,

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who is fourth in the output, but only fifth here, which leads one at once to suppose that he raises more per man, which he does. Then follow Mr. Moore, Mr. Hall, Mr. Dickinson, Mr. Cadman, Mr. Alexander, Mr. Wynne, and Mr. Baker, who is last, but is eighth in output, and he stands second highest as to tons raised per man.

Deaths by Accident.—Mr. Hall stands first as having the most killed, and as he stands pretty high as compared with output and persons employed, he has the worst results as to the ratio of persons employed and tons raised per death. Then comes Mr. Wales, and then only Mr. Bell, who stands first with output and men employed. The fourth is Mr. Wynne, who is followed by Mr. Wardell and Mr. Moore, who are equal; then as seventh comes Mr. Cadman, and Mr. Evans and Mr Willis next, who are equal; and they are followed by Mr. Dickinson, Mr. Alexander, and lastly by Mr. Baker.

Ratio of Persons Employed per Life Lost.—This, and the death rate per 1,000, as coming from the same set of figures, are of equal proportions, and here stands first Mr. Wardell, who is closely followed by Mr. Evans and Mr. Willis; then as fourth comes Mr. Dickinson, being one hundred behind the last; then Mr. Baker, Mr. Alexander, Mr. Bell, Mr. Moore, Mr. Cadman, and Mr. Wales follow; and last comes Mr. Hall, standing only one-third as high as Mr. Wardell, the first.

Ratio of Tons Raised per Death.—This does not follow a close relationship to the last ratio, for here Mr. Bell stands first, who was only seventh in the last, and this s occasioned by his great output, which is proportionally much higher than the persons employed under him as compared with the others. Second stands Mr. Baker, who has the smallest number of men under him. He is followed by Mr. Willis as third, and he again by Mr. Wardell, Mr. Evans, Mr. Moore, Mr. Alexander, Mr. Dickinson, Mr. Cadman, Mr. Wales, Mr. Wynne, and lastly by Mr. Hall, who stands very low, being below half the average for the Kingdom.

Ratio of Tons Raised per Man per Annum. This is interesting from a commercial point of view, and here Mr. Bell is first, owing no doubt to the Cleveland iron-stone district, for, taking this away, he only stands third. Following him closely comes Mr. Baker, and then Mr. Moore, with Mr. Willis next, who is equal to the average of England. The rest are below, being, as sixth, Mr. Alexander, who is followed by Mr. Evans, Mr. Wardell, Mr. Wales, Mr. Hall, Mr. Dickinson, and lastly by Mr. Cadman.

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NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ABSTRACTS OF FOREIGN PAPERS.

ON COBALTITE AND DANAITE FROM THE KHETRI MINES, RÁJPUTÁNA; WITH SOME REMARKS ON JAIPURITE (SYEPOORITE).

By F. R. MALLET, F.G.S. *Records, Geol. Survey of India; Vol. XIV., Part* 2, *pp.* 190–196.

Describes the rare Sulphide of Cobalt, so remarkable for its purity, found in the Khetri (Khetree) Mines, near Jaipur (Jyepoor), in Rájputána. This mineral occurs in thin layers between masses of copper ore, not more than 200 lbs. per month being produced by any mine, and is used by Indian jewellers for staining gold of a delicate rose-red colour by a secret process, and also in forming the well-known beautiful blue enamels of the country. Some doubt seems to be thrown on the existence of Jaipurite as distinct from the Cobaltite just referred to, an analysis of which is as follows:—

Sulphur	19·46
Arsenic	43·87
Antimony	tr.
Cobalt	28·30
Nickel	tr.
Iron	7·83
Gangue	·80
	100·26

The specific gravity is 6·00 exactly, and associated with the mineral are small crystals of Danaite. G. A. L.

ON THE FERRUGINOUS BEDS ASSOCIATED WITH THE BASALTIC ROCKS OF NORTH-EASTERN ULSTER, IN RELATION TO INDIAN LATERITE.

By F. R. MALLET, F.G.S. *Records, Geol. Survey of India; Vol. XIV., Part* 1, *pp.* 139–148.

Describes the iron ores intercalated between the flows of Basalt of Antrim, gives a *résumé* of the various theories which have been brought forward as to their origin, and compares them with the laterite of India. Both the Indian and Irish deposits agree in being "argillaceous, often pisolitic, forms of highly ferruginous rock, the iron in both being mainly in the state of hydrous and anhydrous ferric oxide. Both are

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associated over wide areas with underlying beds of lithomarge, and both are intimately connected *in some way* with volcanic rocks" (page 145). The points of difference are, on the other hand, not of essential importance. The author then favourably considers whether the view taken by the Irish geologists, and notably by Mr. Kinahan, as to the origin of the Antrim beds, may be applicable to some of those in India. He accordingly concludes that the high percentage of iron in the high-level laterite, as well as its tolerably uniform diffusion over wide areas, seems to be explained by regarding that rock as of lacustrine and (in so far as the iron is concerned) of chemical origin.

G. A. L.

[*Note by Sub-Editor.*—This paper is specially interesting when read in connexion with Mr. Kendall's paper on "The Iron Ores of Antrim," in the Institute Transactions.—G. A. L.]

THE SOEKABOEMI COAL-FIELD.

Onderzoekingen in het kolenterrein bij Soekaboemi; by J. A. Hooze. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië; 11 Jaargang, Part 1 (Wetensch. gedeelte), pp. 5–65, with large folding Geological Map.*

The rocks of this portion of Java consist of Tertiary sedimentary beds overlying and sometimes broken through by eruptive masses of various ages. Verbeek has divided the Eocene of Sumatra into four Groups or Stages. Of these only the second and fourth are represented here, the latter lying perfectly conformably upon the former. Equally conformable upon the fourth Eocene Stage are beds of Miocene age, which with Drift and Alluvial deposits make up all the sedimentary rocks of the coal-field. The country is hilly, and the beds lie in broad synclinals and anticlinals, the latter generally occupying the valleys, and the former, as usual, having better resisted denudation, forming the hills. There are limestones, sandstones, and conglomerates of both Miocene and Eocene age, and the coal-seams occur in the non-calcareous members of either series. Upon the denuded edges of the Tertiary beds, and constituting the greater part of the surface of the country—all the lower ground, in fact—are sheets of volcanic lava of comparatively recent overflow. This consists chiefly of Augite-Andesite. A similar rock is supposed to be of greater age. The other igneous rocks are Basalt and Hornblende-Andesite. There are several faults which are noticeable for their low hade or deviation from the vertical. The coal-seams described vary from 0·10 metre to 2 or even 4 metres in thickness. Full analyses of the various coals are given, in which the percentage of carbon ranges from 69·15 to 74·76, with an average of 71·20, and that of ash from 5·46 to 11·10, with an average of 7·64. G. A. L.

CHINESE GOLD MINE IN BORNEO.

De geologisch-mijnbouwkundige Opneming van een gedeelte van Borneo's-Westkust. Verslag No. 2. Beschrijving der Chineesche goudmijn Sim-pi-toe. By C. J. Van Schelle. *Jaarboek van het Mijnwezen in Nederlandsch Oost-Indië; 11 Jaargang, Part 1 (Technisch gedeelte), pp. 27–44, with three Plates.*

The gold mine of Sim-pi-toe is in the valley of the Bani River on the west coast of Borneo, on the road between Sjoei-Tsiet and Selinsé and about five kilometers from Benkajang. It was opened in 1874, and produces yearly about 17,175 *thail* (1 Borneo *thail* of gold = 54 grammes) of gold, having a value of about 13,000 gulden. The mine is in gravel and drift older than the alluvium of the Bani River, and lying upon

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a floor of granite. The Chinese machinery and implements used at the mine are fully described and figured. Plate 1 is a coloured geological map and section across the workings, which have been carried down as far as the bottom rock or granite. This paper is one of a series of mining and geological reports on the west coast of Borneo.

G. A. L.

NOTES ON MINING RECORDS AND THE MINING RECORD OFFICE OF GREAT BRITAIN; AND THE COAL AND METALLIFEROUS MINES ACTS OF 1872 (ENGLAND).

By T. W. H. Hughes, F G.S., etc. *Records, Geol. Survey of India; Vol. XIV., Part* 2, *pp.* 185–190.

Describes the publications and institution first-mentioned in the title with the object of showing how useful would be the establishment of similar ones in India. Incidentally it is noted that the output of the most abundant Indian mining produce, *coals*, was (for 1878) only about 1,000.000 tons, made up as follows:–

	Tons.
Ráníganj Coal-field	522,000
Karhárbári ,, ...	434,000
Wardha Valley ,, ...	45,000
Mohpáni ,, ...	13,000

Notes that if the prohibition of female labour underground were extended to India, the result would be disastrous; also (with regard to the clause in the English Act prohibiting the payment of wages in public-houses) that in India "it is asserted that grog shops are most useful in stimulating the industry of the miners, for as long as they have money they won't toil. Having spent the last of their wages over a beaker of 'dáru,' they proceed to work. Consequently the greater the facilities for drinking, the more sustained their industry."

G. A. L.

PETROLEUM AND OZOKERITE IN EASTERN GALICIA.

Die Petroleum- und Ozokerit-Vorkommnisse Ost-galiziens. By C. M. Paul. *Jahrbuch der k.-k. geol. Reichsanstalt; Vol. XXXI., No.* 1, *pp.* 131–168, *with ten Figures in the text.*

The following are the divisions recognized in the Carpathians of Eastern Galicia (in ascending order):—1.—The Neocomian Ropianka Beds, or Lower Carpathian Sandstone. 2.—The Middle Carpathian Sandstone. 3.—The Eocene Carpathian Sandstone. 4.—The Menilite Slates. 5.—The Magura and Kliwa Sandstones. 6.—The Neogene Salt Clay.

Of these Nos. 1, 3, 4, and 6 alone are oil-bearing. Sections across the oil-bearing districts are described and in some cases illustrated. At Rozpucie, Roschy, Kreciata, Mraznica, and Orow, the oil-bearing portions of the Ropianka series occupy the anticlinal axes of the folded and contorted beds in a very striking manner. This is also the case, though perhaps less conspicuously so, with the Eocene localities in the basins of the San, Dnjester and Strwiaz, Stryj and Opor, and at Mizun and elsewhere in the easternmost part of Galicia. The "mineral wax" or Ozokerite occurs in the Neogene Salt Clay, where the beds are so contorted as to be apparently beneath the really underlying Menilite Slates. Boryslav, where this inversion takes place, is the chief locality for this substance, which is found in exactly the same position as that occupied by the petroleum in the older beds, namely, along the axis of a sharp saddle fold or anticline.

G. A. L.

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A MINERAL SPRING IN THE COAL-MEASURES OF THE SOUTH OF FRANCE.

Note sur une Source minérale rencontrée dans une galerie des houillères de Gagnières (Gard). *By* M. PARRAIN. *Bulletin, Soc. Géol. de France; Sér.* 3, *Vol. IX., pp.* 221, 222.

This spring was struck at a depth of 250 metres from the surface (47·6 metres above sea-level), in driving a gallery in the Gagnières Colliery (Department of Gard). The rocks were shales and fine fissured sandstones. The temperature of the water was 19° C. On evaporation 10,520 grammes of solid matter was left per litre of water. The analysis of this residuum is as follows [analysis given here exactly as by the author]:—

	Grammes.
SiO^2	Traces.
CaO	0·500
MgO	0·150
Fe^2O^3, Al^2O^3	Traces.
SO^3	3·944
Cl	0·247
Alkalies	5·056
HO and CO^2	0·600
	10·497

The water gives rise to a considerable calcareous and magnesian deposit in the workings. G. A. L.

COAL-FIELDS OF THE PYRENEES.

Sur la Géologie des Pyrénées de la Navarre, du Guipuzcoa, et du Labourd. *By* P. W. STUART-MENTEATH. *Bulletin, Soc. Géol. de France; Sér.* 3, *Vol. IX., pp.* 304–333. *With folding Map (geological) and seventeen Figures in text.*

This paper is one on the detailed geology of the regions named in the title, and includes descriptions of deposits of Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, and Cretaceous age, as well as serpentines (ophite), granites, porphyries, and other highly altered and igneous rocks. The small coal-fields of La Rhune and Ibantelli were known before, but the author adds considerably to our knowledge of their stratigraphical and palæontological relations. They belong to the same horizon as the Upper Carboniferous of Saint-Etienne, occur in irregular folded strata conformably underlying beds regarded as Permian by Mr. Menteath, and are bounded by faults of large throws. Beneath the Coal-Measures, though often not very clearly or satisfactorily shown either as to position or fossils, is a series of marbles and other calcareous and more or less metamorphosed deposits and cherts, which is described and mapped in the present paper as Lower Carboniferous of Carboniferous Limestone age. In this view the writer follows Dr. Ch. Barrois, who in 1881 gave, for the first time, palæontological proof of the Lower Carboniferous age of the well-known *marbres griottes* of the Pyrenees. The map is on the scale of 1 : 200,000.* G. A. L.

* [See also on this subject a Note by Prof. Hébert, *Bull. Soc. Géol. France*, Sér. 3, pp. 179–181.]

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THE DIAMOND FIELDS OF SOUTH AFRICA.

Note sur la Région diamantifère de l'Afrique Australe. *By* M. CHAPER. *Bulletin, Soc. Géol. de France; Sér.* 3, *Vol. IX., pp.* 8, 9.

A brief account of a separate work published on this subject by the writer. In this work the geological features of the diamond deposits of Griqualand West are given. These deposits the author regards as having been thrown up in a very fluid condition, at a low temperature, and at repeated intervals. The manner in which the materials in question, after ejection and consolidation, were depressed and dislocated, is considered, and dykes of serpentinous (ophitic) matter cutting through them, are described. The formation of various products of emanation and especially of the zeolites accompanying the diamond rocks is explained. The other minerals found associated with the gems—garnet, titaniferous iron. hæmatite, sahlite, vaalite, etc.—are described by M. Friedel, and the rocks themselves by MM. Fouqué and Michel-Lévy. The general result of these combined studies is the view that the diamond has not been torn away from a pre-existing rock, but is found in its original mother-rock or gangue. A map, three plans, and eight plates illustrate the original work. G. A. L.

PERMO-CARBONIFEROUS ROCKS OF AUTUN.

Sur les Fossiles du Terrain Permien d'Autun (Saône-et-Loire). *By* M. E. ROCHE. *Bulletin, Soc. Géol. de France; Sér.* 3, *Vol. IX., pp.* 78–83.

The Autun district, so long known for the *bituminous* shales worked there, is specially interesting as affording one of the best-studied examples of a perfect passage from Coal-Measures to Permian. These oil-shales are divided into three easily-distinguished divisions:—

1.—A lower sub-stage, 150 to 200 metres thick, comprising the beds worked at Igornay and Saint-Léger-du-Bois. This division lies quite conformably upon true Coal-Measures (worked for coal at Grand-Moloy and elsewhere), and contains plants chiefly characteristic of the latter series, but mixed with a very few Permian species. The animal remains, however, have a much less Coal-Measure facies. They are:—CRUSTACEA—*Cyproïdes, Nectotelson;* FISHES—*Palæoniscus, Amblypterus, Acanthodes, Pleuracanthus;* SAURIANS—*Actinodon Frossardi, Euchyrosaurus Rochei, Stereorachis dominans.*

2.—A middle sub-stage, of more than 300 metres thick, comprising the beds worked at Lally, Muse, Cordesse, Dracy-Saint-Loup, Ravelon, La Camaille, and Le Ruet. In this division Permian plants, including several species of *Callipteris* and *Walchia*, are much more numerous, although many Carboniferous species are still common. The animal remains are much the same as in the lower sub-stage, with the addition of *Actinodon major* among the SAURIANS, and the interesting BATRACHIANS, *Protriton petrolei* and *Pleuronoura Pellati.*

3.—An upper sub-stage, known as the *Boghead* beds, about 500 metres thick, and comprising a seam of so-called *Boghead* coal, which has been worked at Surmoulin, Millery, and Margennes—all in the neighbourhood of Autun. In this division the plants are almost all of strictly Permian species, with a very few forms characteristic of the Coal-Measures. The animal remains are the same as in the middle division, with the exception of the Saurians which have not been found here. G. A. L.

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COQUILLION'S APPARATUS FOR ANALYSING FIRE-DAMP.

Note sur l'appareil Coquillion pour l'analyse du Grisou, etc. Par M. CASTEL, *Ingénieur en Chef des Mines. Annales des Mines; Sér. 7, Tome XX.*, 1881, *pp. 509 to 534.*

The principle of the invention, which dates from 1877, is the property possessed by carburetted hydrogens of combustion in contact with a red hot palladium wire in oxygen, leaving a product of water and carbonic acid. By condensing the water, and comparing the volumes before and after combustion, the proportion of carburetted hydrogens can be estimated. In mixtures up to nine per cent. of fire-damp and air the apparatus is reliable. Tables of seventeen different experiments with products are given in the paper. D. P. M.

THE SEAHAM AND PENYGRAIG EXPLOSIONS.

Note sur les Explosions survenues dans les houillères de Seaham et de Penygraig. Par M. L. AGUILLON, *Ingénieur des Mines. Annales des Mines; Sér. 7, Tome XX.*, 1881, *pp. 209 to 247. Plates III., IV., and V., fig.* 1.

The interesting account of these two accidents, which occupies some forty pages, deserves more than a mere summary; but as all the details and the voluminous reports are still fresh in the minds of the members of the Institute, a notice of the conclusions will be sufficient.

1.—SEAHAM.

The author states that it is plainly apparent that the explosion could not have occurred in any working place *(chantier)*, and that the seat must be looked for within a radius of 800 yards from the shaft in one of the main intakes. The returns and the furnaces are evidently out of the question. The evidence tendered on behalf of the owners, and of the engineers employed by them, seems to place the site of the explosion to Ramshaw's place, whose body and lamp were found shattered. The men's representatives and the Government Inspectors disputed energetically this view, and the former attribute it to an oil lamp at an interior staple, and their theory has this in its favour, that the air, having the choice of two seams, might have become stagnant in the staple, and gas accumulated there.

The Government Inspectors seem to refer the point of ignition nearer to the downcast, *i.e.*, at the curve cross-cut. As this would depend on a shot (which has not been ascertained to have been blown out), the combustion of coal dust, on which their theory depends, does not appear proved. In fact, unless Professor Abel's experiments are set aside, nearly 2½ per cent. of fire-damp would have to be present. In dismissing this view the writer agrees with one witness, that if a shot could light up in so vehement a manner coal dust alone, most of the collieries in the North of England would have long ere now ceased to exist. The author gives, as his own opinion, that the main question was entirely left out of the inquiry, viz., the *general arrangement of airways and workings*. He also points out that nearly the whole of the victims perished by suffocation from after-damp at periods of various duration, and that this should be a warning to English mining engineers to investigate the subject of extensive goaves and numerous ramifications of intercrossing airways. A comparatively small explosion may destroy all crossings, stoppings, and doors, and immediately the miles of workings become dead (*culs de sac*). The author is, therefore, of opinion that some system by which the upcast should be placed at the extreme rise would obviate to some extent the dangers arising from the present system of neighbouring pits. and complicated airways depending on crossings and separation doors.

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2.—Penygraig.

The conclusions arrived at in this case are very similar to the foregoing. The workings were all dependent on crossings, and in the disablement of these became so many *culs de sac*. In addition the mine was fiery, and powder extensively used. In neither of the two cases can dust be charged specially with the disaster, but both accidents point to defective arrangements of workings and airways. D. P. M.

MINERAL AND METALLURGICAL STATISTICS OF SPAIN, 1871-75.

Statistique Minière et Métallurgique de l'Espagne. Par M. Coignet. *Bulletin de la Société de l'Industrie Minérale; Sér. 2, Tome X.*, 1881, *pp.* 412-415.

1.—Ores.

Provinces.	1871.	1872.	1873.	1874.	1875.		
	Production.	Production.	Production.	Production.	Production.	Value per Ton at the Pit.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Francs.	£ s. d.
Iron Ore—							
Biscaye ...	403,142	402,000	365,340	10,821	34.296	2·30	1·84
Oviédo ...	38,080	51.207	56,628	65,875	59,195	2·60	2·08
Santander ...	35,480	40,364	60,966	78,836	69.000	8	6·4
Malaga ...	31,025	36,900	51.000	52.645	42,283	5·15·50	4–12·4
Murcie ..	29,354	65,000	118.018	110,836	190.626	3·50	2·80
Almérie ...	12,767	56.589	72.770	75,120	82.960	6	4·8
Guipuzcoa ...	12,500	30,554	34,020	10,681	17,038	10	8
Navarre ..	6.879	24,300	19,920	9,175	13.462	16	12·8
Séville ...	3,295	3,473	23,000	3.320	3.500	5·20	4·16
Others ...	13,240	11.081	10,264	6,092	7,734	...	...
Total ...	585,762	721,468	811,926	423,401	520,094	...	...
Non-argentiferous Lead Ore—							
Murcie ...	283.953	231.580	118,782	132 568	184,744	20	16
Jaen ...	72,748	93,682	69,315	65,018	87.855	...	...
Almérie ...	25,490	28,641	21,334	13,684	12,767	235	9 8
Badajos ...	11.900	14,814	4.522	6,420	10,316	200	8 0
Cordone ...	2,290	770	1,604	1,186	1.040	240	9 12
Grenade ...	1.896	1.292	...	4.488	4,016	140	5 12
Others ...	4,512	3,064	2,978	4,196	3,740	...	...
Total ...	402,789	373,843	218,535	227,560	304,478	...	...
Argentiferous Lead Ore—							
Almérie ...	26,566	31,373	33,437	55,431	30.118	217	8 13 6
Ciudad-Real ...	1,297	1,431	1,856	2,619	2,706	600–870	£24–£34 16·0
Badajos ...	1.100	...	...	150	580	530	21 4
Guipuzcoa ...	1.084	1,316	892	260	...	...	...
Tolède ...	250	...	130	1,600	...	...	...
Others ...	489	260	189	280	176	...	...
Total ...	30,786	34,380	36,504	60,340	33.580	...	...
Silver Ore—							
Almérie ...	12,380	5,880	50,000	32,605	35,831	95	3 16
Guadalajara ...	855	1.037	650	701	549	764·70	30 11·76
Séville ...	30	17	...	...	...	...	...
Grenade ...	...	10	...	...	...	...	...
Total ...	13,265	6,944	50,650	33,306	36,380	...	...

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ORES.—*Continued.*

PROVINCES.	1871. Production.	1872. Production.	1873. Production.	1874. Production.	1875. Production.	1875. Value per Ton at the Pit.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Francs.	£ s. d.
Copper Ore—							
Huelva ...	489.691	497,644	298,580	539,889	783,787	27–46	£1 1 6–£1 16 8
Séville ...	7,214	6,080	33,120	19,303	17,703	20	16
Almérie ...	458	461	484	405	335	195	7 16
Santander ...	320	2,070	464	100	120	300	12 0
Oviédo ...	260	430	345	80	...	...	...
Others ...	263	655	93	564	688	...	...
Total ...	498,206	507,340	333,086	560,341	802,633	...	...
Zinc Ore—							
Santander ...	81,708	67,609	65,127	70,148	71,587	55	2 4
Murcie ...	11,705	9,850	30,563	31,896	21,749	32·50	1 6
Almérie ...	6,691	6,073	3,700	3,543	4,695	50	2 0
Oviédo ...	2,630	860	130	20	...	...	...
Alava ...	1,089	1,123	...	...	...	...	...
Teruel ...	940	400	200	...	250	50	2 0
Biscaye ...	860	1,065	...	...	...	...	...
Guipuzcoa ...	762	660	10	...	...	...	...
Others ...	995	1,731	1,280	870	1,892	...	...
Total ...	107,380	89,371	101,010	106,477	100,173	...	...
Manganese Ore—							
Huelva ...	12,217	27,055	15,511	8,765	13,350	80	3 4
Oviédo ...	1,375	3,200	1,920	1,620	600	70	2 16
Séville ...	1,482	1,530	177	77	...	...	...
Almérie ...	194	141	107	105	70	50	2 0
Teruel ...	...	800	264	502	600	15	12
Others ...	...	...	75	...	90	...	...
Total ...	15,268	32,726	18,054	11,069	14,710	...	...

2.—METALS IN 1875.

METALS.	Weight.	Value.	
		Francs.	£ s. d.
Cast iron	36,900 tons	4,729,074	189,162 9·2
Wrought iron	2,057 ,,	917,273	36,690 18·4
Steel	149 ,,	157,200	6,288 0
Lead	107,766 ,,	49,083,825	1,963,353 0
Argentiferous lead	11,887 ,,	10,317,829·20	412,713 3·36
Silver	5,913·74 kilogs.	1,280,574·80	51,222 9·84
Copper	6,633 tons	9,436,500	377,460 0
Tin	1,200 kilogs.	2,640	105 12
Zinc	3,831 tons	2,028,159	81,126 7·2
Mercury	1,426 ,,	14,590,963·70	583,638 0·96
Soda	801 ,,	56,063	2,242 10·4
Alum	352 ,,	63,342	2,533 13·6
Sulphur	3,056 ,,	568,851·25	22,754 1
Cement	8,000 ,,	200,000	8,000 0
Total	.....	93,432,294·95	.....

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3.—Exportation.—Ores and Metals.

Ores and Metals.	1871.	1872.	1873.	1874.	1875.
	Tons.	Tons.	Tons.	Tons.	Tons.
Ores—					
Iron	391,436	745,802	800.381	711,127	336,604
Lead, argentiferous or otherwise	1,168	3,384	4.661	8,146	9.954
Copper	247,223	271,484	255,969	289,876	362,478
Tin	13	9	...	2	...
Zinc	33,807	43,503	46,562	66,169	42,777
Mercury	...	5	...	...	...
Antimony	20	46	...	25	...
Cobalt	...	...	...	1	47
Manganese	23,868	29,799	29,056	41,936	13,953
Sulphur	100	...	...	710	...
Phosphate of lime	33,417	45,559	11,842	100	19,193
Iron pyrites	250	6,954	1,570	464	...
Metals—					
Wrought iron and tools ...	417	2,173	682	1,421	907
Steel	55	...	...	16	...
Pig lead	45,099	44,855	32.780	37,697	40,200
Argentiferous lead in pigs ...	45.335	49.850	38,201	46,637	51,529
Refined copper	1.424	358	1,295	81	38
Cement copper	3,604	3,684	4,449	4,417	...
Tin	...	1	...	...	...
Zinc in bars and sheets ...	1,531	1,030	1,992	1,336	1.178
Mercury	586	1,369	1,218	1,375	1,716
Argentiferous litharge	...	9	...	1	...

J. H. M.

MINERAL STATISTICS OF PORTUGAL, 1866-1876.

Tableau de l'exportation des principaux minerais extraits des mines, de 1866-1876, *par* M. Coignet. *Bulletin de la Société de l'Industrie Minérale; Sér.* 2, *Tome X.*, 1881, *p.* 416.

Table showing Exportation of Ores.

Years.	Lead.			Copper.			Tin.			Iron and Manganese.			Phosphate of Lime.		
	Tons.	Value.		Tons.	Value.		Tons.	Value.		Tons.	Value.		Tons.	Value.	
		Frs.	£ s. d.		Frs.	£ s. d.		Frs.	£ s. d.		Frs.	£ s. d.		Frs.	£ s. d.
1866	..	..	..	(?) 915	6,969,844	278,793 15 2	..	..	..	619	59,533	2,381 6 4	7	..	..
1867	239	72,472	2,898 17 0	111,873	5,471,23[illegible]	218,849 6 4	..	..	..	1,809	103,616	4,144 12 8	48	4,083	163 6 0
1868	951	136,972	5,478 17 0	85,693	4,398,383	175,935 6 4	..	..	..	5,223	498,500	19,940 0 0	469	23,161	926 8 8
1869	2,516	383,02[illegible]	15,320 17 6	140,738	7,011,494	280,459 15 2	..	..	..	12,994	442,661	17,706 8 8	72	12,500	500 0 0
1870	1,039	237,938	9,517 10 4	274,363	9,178,966	367,158 12 8	10	14,861	594 8 8	14,428	650,872	26,035 17 6	408	17,027	681 1 6
1871	2,328	316,788	12,671 10 4	117,667	5,673,7[illegible]	226,948 4 0	129	30,477	1,219 1 6	4,442	217,616	8,704 12 8	..	.	..
1872	1,593	349,466	9,978 12 8	181,689	9,077,688	363,107 10 4	91	43,861	1,754 8 8	21,444	1,424,388	56.975 0 4	1,817	97,34[illegible]	3,893 15 2
1873	1,407	260,305	10,412 4 0	222,025	11,027,777	441,111 1 6	56	91,372	3,654 17 6	30,945	1,303,316	52,132 12 8	154	8,555	342 4 0
1874	1,127	308,316	12,332 12 8	168,054	8,275,72[illegible]	331,028 17 6	28	26,005	1,040 4 0	35,009	1,216,450	48,658 0 0	356	11,300	452 0 0
1875	863	278,550	11,142 0 0	167,77[illegible]	8,809,155	352,366 4 0	33	16,494	659 15 2	43,822	787,572	31,502 17 6	4,479	164,355	6,574 4 0
1876	1,289	456,744	18,269 15 2	61,773	3,155,200	126,203 0 0	58	21,577	863 1 6	21,569	559,505	22,380 4 0	2,902	76,550	3,062 0 0

J. H. M.

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THE ACTION OF ZINC IN BOILERS.

Sur l'action de présence des feuilles de zinc dans les chaudières, et sur un procédé pour en éviter les explosions. Note de M. Trève. *Comptes rendus; Tome XCV., pp.* 522-524.

Since 1875 experiments have been made in the French navy on the use of zinc for the prevention of incrustation.

The boiler plates and zinc form a battery which decomposes the water into its elements, hydrogen and oxygen. The oxygen, combining with the zinc, forms zinc oxide, which enters into combination with the fatty acids, and mixes with the water. Zinc *soap* is produced which prevents the salts thrown down by vaporization from adhering to the plates. One stroke of a brush is sufficient to remove them.

The hydrogen disengaged tends to aerate the water, and thus the danger of explosion from superheating is much lessened. The author thinks, however, that this action, good in theory, may not always be realized in practice, and recommends the completion of it by mechanical means under the form of a moderate but continuous injection of hot air into the lower part of the boiler, or better still of a non-oxidizable gas, such as carbonic acid.

J. H. M.

THE THOMAS-GILCHRIST PROCESS.

Discussion sur la Déphosphoration. Par M. Rocour. *Bulletin de l'Assoc. des Ingénieurs sortis de l'École de Liége; Nouvelle série, Tome V.*, 1881, *pp.* 8-16.

In the course of his paper, M. Rocour gives the following analysis of the first twenty-five tappings made at Montluçon in December, 1880.

	Iron.			Steel.			
Nos.	Si.	Mn.	Ph.	C.	Si.	Mn.	Ph.
1	1·43	1·80	1·59	0·31	0·06	0·43	0·05
2	0·47	1·62	...	0·29	0·04	0·57	0·09
3	1·10	1·76	...	0·26	tr.	0·54	0·09
4	1·03	1·58	...	0·24	tr.	0·57	0·06
5	1·15	1·69	1·51	0·37	0·03	0·32	0·08
6	0·95	1·29	1·55	0·35	tr.	0·36	0·11
7	0·76	1·36	...	0·32	0·05	0·68	0·03
8	0·68	1·33	1·76	0·26	0·02	0·43	0·07
9	0·67	1·04	...	0·42	0·05	...	0·04
10	0·67	0·97	...	0·42	tr.	...	0·05
11	...	...	...	...	...	...	0·08
12	0·79	1·22	...	0·40	0 05	0·54	0·10
13	0·78	1·18	...	0·43	0·02	0·54	0·07
14	1·02	2·03	...	0·35	tr.	0·46	0·06
15	0·95	1·49	1·68	0·37	0·08	0·75	0·06
16	0·90	1·76	...	0·38	0·04	0·54	0·05
17	0·75	1·33	...	0·38	0·04	0·54	0·07
18	0·75	1·00	...	0·45	0·02	0·82	0·07
19	1·00	1·70	...	0·38	tr.	0·54	0·05
20	0·68	0·95	...	0·46	0·02	0·82	0·04
21	0·64	1·29	...	0·48	tr.	0·57	0·05
22	0·65	1·40	...	0·53	tr.	0·68	0·03
23	0·54	1·29	1·61	0·39	0·03	0·50	0·03
24	0·40	1·08	...	0·46	tr.	0·68	0·04
25	0·90	1·54	...	0·49	0·04	0·82	0·03

J. H. M.

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INDUSTRIAL MAP OF THE GARD COAL-FIELD.

Carte industrielle du bassin du Gard. Par M. GARREAU. *Bulletin de la Société de l'Industrie Minérale; Sér. 2, Tome XI., 1882, pp.* 539-540. *Plates XV., XVI.*

Plate XV. is a geological map on the scale of $\frac{1}{80000}$, showing the royalties, both coal and metalliferous.

Plate XVI. contains diagrams showing the production of coal, iron pyrites, and zinc from 1860 to 1880 inclusive. From these it appears that the output of coal has increased with more or less regularity from 900,000 tons in 1860 to 2,000,000 tons in 1880.

M. Garreau also gives a geological section of the strata. J. H. M.

THE CANALISATION OF THE SEINE.

Paris Port de Mer. Par M. BOUQUET DE LA GRYE, *pp.* 507–523. *Création d'un Port de Mer à Paris. Par* M. EDMOND ROY, *pp.* 524–538. *Discussion pp.* 555–568, 594–606. *Mémoires et Compte Rendu des Travaux de la Soc. des Ingénieurs Civils;* 1882. *Vol. I.*

These papers discuss the question of the conversion of the river Seine into a ship canal, as far as Paris. M. Bouquet de la Grye is in favour of the scheme, M. Edmond Roy is opposed to it. Amongst other objections the latter thinks that coal could then be conveyed without transhipment direct from England to Paris to the exclusion of French coal from the Pas de Calais. He favours the construction of the Grand Northern Canal connecting Paris with its northern coal-fields, by means of which the freight of coal would be reduced from its present figure 5·20—5·60 shillings (6·50—7·00 fr.) per ton to 2·80—3·20 shillings (3·50—4·00 fr.), thus benefiting both the city of Paris and the Pas de Calais coal-field. J. H. M.

INDUSTRIAL LEGISLATION.

La liberté des mesures contre les accidents industriels. Par M. GEORGES SALOMON. *Mémoires et Compte Rendu des travaux de la Soc. des Ingénieurs Civils.* 1882. *Vol. I. pp.* 653-686.

M. Louis Ovière has addressed a petition to the Chamber of Deputies, asking that *Articles 14 and 16 of the law of the 19th May, 1874, on the employment of *children*, should be extended so as to include *adults* employed in all trades, agricultural as well as industrial.

The Chamber of Deputies sent the petition to the Minister of Agriculture and Commerce, who has opened an inquiry through the Préfets, by means of a circular dated 5th April, 1880. This has met with a hearty response, and M. Salomon proposes that the matter should be considered by the Institute of Civil Engineers.

M. Salomon reviews the industrial legislation of England, Germany, France, and Switzerland, and in an appendix gives extracts from their laws. He also quotes the rules of two private societies for the prevention of accidents in workshops, viz.:—

The Mulhouse Association for the Prevention of Accidents from Machines; and the Rouen Association formed in December, 1879, for the same purpose.

On the whole he seems to think that the formation of such societies as the above would work better than Government legislation, and recommends that each industry should issue a hand-book of its trade, to point out how accidents may be prevented, and also to be an industrial text-book for the use of students and workmen. J. H. M.

* Art. 14.—The workshops shall be kept clean and properly ventilated. They shall have all the conditions of security and salubrity necessary for the health of children. Moving machinery, traps, etc., must be fenced. Art. 16.—Inspectors shall be appointed to see that the law is carried out.

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PRICES OF COAL AND COKE AT ST. ETIENNE.

Prix-Courants des Charbons et Cokes à St. Etienne. Bulletin de la Société de l'Industrie Minérale, Sér 2, Tome X. 1881, *p.* 263 *and p.* 643; 1882, *p.* 341.

Kind of Coal.	Price per Ton of 2,204 lbs. 25th June, 1881.	31st Jan., 1882.	15th July, 1882.
	s. s.	s. s.	s. s.
Large hard hand picked coal, 1st quality	28·8 to — ...	28·8 to — ...	28·8 to —
Large tender hand picked coal, good quality	21·6 — 23·2 ...	21·6 — 23·2 ...	20·8 — 23·2
Large tender hand picked coal, ordinary quality	18·4 — 20·0 ...	20·0 — 20·8 ...	20·0 — 20·8
Screened, 1st quality	18·4 — 21·6 ...	18·4 — 21·6 ...	16·8 — 21·6
Do. 2nd do.	15·2 — 17·6 ...	15·2 — 17·6 ...	15·2 — 16·8
Nuts, washed	15·2 — 16·0 ...	14·4 — 16·8 ...	14·4 — 16·8
Do. unwashed	11·2 — 12·8 ...	11·2 — 12·8 ...	11·2 — 12·8
Gas coal, 1st quality	15·2 — 16·0 ...	15·2 — 16·0 ...	15·2 — 16·0
Do. 2nd do.	14·8 — 15·2 ...	14·8 — 15·2 ...	13·6 — 15·2
Smiths' coal, 1st quality ...	18·4 — 20·0 ...	18·4 — 20·0 ...	18·4 — 20·0
Do. 2nd do. ...	16·0 — 16·8 ...	16·0 — 16 8 ...	16·0 — 16·8
Do. washed	14·4 — 15·2 ...	14·4 — 15·2 ...	14·0 — —
House coal, 1st quality ...	12·0 — 12·8 ...	12·0 — 13·6 ...	12·0 — 13·6
Do. 2nd do. ...	11·2 — — ...	11·2 — — ...	11·2 — —
Small coal for large forgings	1·04 — 11·2 ...	10·4 — 11·2 ...	10·4 — 11·2
Do. lime burning ...	7·2 — 8·0 ...	7·2 — 8·0 ...	7·2 — 8·0
Do. average quality ...	8·0 — 8·4 ...	8·0 — 8·8 ...	8·0 — 8·8
Washed coke, 1st quality ...	28·0 — 30·4 ...	28·0 — 30·4 ...	28·0 — 30·4
Do. 2nd do. ...	22·4 — 24·0 ...	22·4 — 24·0 ...	22·4 — 24·0
Coke for blast furnaces ...	19·2 — 20·0 ...	— — 20·0 ...	20·0 — 20·4
Small house coke, good quality	16·0 — 18·4 ...	16·0 — 18·4 ...	16·0 — 18·4
Small coke cinders	8·0 — 12·4 ...	8·0 — 12·4 ...	8·0 — 12·0

J. H. M.

THE VELOCITY OF PROPAGATION OF EXPLOSIONS.

Nouvelles recherches sur la Propagation des phénomènes explosifs dans les Gaz; Par MM. BERTHELOT ET VIEILLE. *Comptes-rendus, XCV., pp.* 151–157.

This paper contains an account of further experiments (see Vol. XXXI., p. 8 Abs.) made with various gaseous mixtures, fired in a caoutchouc tube 131·32 feet (40 m.) long and 0·197 inch (0·005 m.) in diameter. The results are shown in five tables, including altogether nearly fifty different mixtures, from which the following have been selected:—

C = the density of the products of combustion, air being taken as unity.

n = the number of the molecular volumes of the elements that take part in the reaction assumed to be gaseous, viz., $n \left\{ 22{\cdot}32 \times \frac{H}{760} \times (1 + a\,t) \right\}$. Lit.

Q = units of heat produced by the reaction.

T = the theoretical temperature = $\frac{Q}{n \times 6{\cdot}8}$.

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θ = the theoretical velocity of propagation of the explosion in metres per second

$$= 29{\cdot}354 \sqrt{\frac{T}{C}}.$$

V = the velocity got by experiment.

	C.	n	Q.		$\sqrt{Q}$.		T.		θ		V.	
			French.	English.	Fr.	Eng.	Cent.	Fah.	Metrs.	Feet.	Metrs.	Feet.
$H_2 + O$	0·622	1·5	59,000	234,130	243	484	5,780°	10,436°	2,831	9,285	2,810	9,216
$CH_4 + O_4$	0·923	4·5	193,500	767,808	440	881	6,320	11,408	2,427	7,962	2,287	7,503
$CH_4 + N_4 + O_4$ ...	0·942	6·5	193,500	767,808	440	881	4,378	7,912	2,002	6,566	1,858	6,096
$CH_4 + N_4 + O_4$ ...	0·951	8·5	193,500	767,808	440	881	3,347	6,057	1,744	5,720	1,151	3,775
$CH_4 + N_{15\cdot04} + O_4$ (Marsh gas + air).	0·958	12·0	193,500	767,808	440	881	2,371	4,300	1,450	4.756	The explosion not propagated.	

J. H. M.

THE MOUNT VISO TUNNEL.

Le Pertuis du Viso, étude historique d'après des documents inédits du Quinzième Siècle, conservés aux Archives Nationales de Turin, par Louis Vaccarone. Communiquè par M. REY, *Mémoires de la Soc. des Ing. Civ.*, 1882, *pp.* 168-171.

Tradition has attributed the piercing of Mount Viso to different people; to Hannibal, the Romans, and the Saracens; but the researches of M. Vaccarone amongst the archives of Turin prove that it was made by Louis II., Marquis de Saluces, in 1480.

The tunnel connects the valley of the Po with that of Queyras in Dauphiné, and is 9,560 feet above the level of the sea. The dimensions were 80 yards long by 10 feet broad and 8 feet high, and the cost 12,000 florins. In 1588 the Duke of Savoy, Charles Emmanuel, blocked the tunnel up, but it was re-opened by Bonaparte in 1803.

J. H. M.

THE TRANSMISSION OF POWER BY ELECTRICITY AT THE BLANZY MINES.

Transport de Force par l'électricité. Expériences faites aux Mines de Blanzy pour déterminer le rendement pratique. Par M. GRAILLOT. *Bulletin de la Société de l'Industrie Minérale; Sér 2, Tome XI.* 1882, *pp.* 89-99. *Plates IV.-VI and three Tables.*

These experiments were made with an electric gin intended to draw coal up a bank at the Saint Chamond pit. The gin was set up under a set of shear legs, carrying a pulley, over which a chain was passed. One end of the chain was rolled round the gin drum, the other was attached to weights varying from 13 to 30 cwts. which weights were drawn up to the pulley by the gin. The useful work done varied from 0·73 to 4·30 horse-power.

M. Graillot found that—

1.—The length of the conductors had no sensible effect upon the useful work done within the limits of his experiments, viz., 700 yards.

2.—The useful effect reached a maximum of 51½ per cent. when the machines (Gramme) were working to their full power.

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The useful effect was obtained by comparing the work in weight raised with the power transmitted to the generating machine. The loss therefore includes that due to the friction of the gearing, etc., of the gin; to the friction of the friction cones connecting the Gramme machine with the gin; to the friction of the pulley on the shear legs; and to that of the chain passing over the pulley and round the drum.—J. H. M.

ELECTRIC GIN, PÉRONNIÈRE COLLIERY.

Application de l'électricité comme transmission de force aux Mines de la Péronnière. *Par* MM. CHAROUSSET *et* BAGUE. *Bulletin de la Société de l'Industrie Minérale; Sér 2, Tome XI.* 1882, *pp.* 5–88. *Plates I.–III.*

In this paper the authors give a detailed account, with numerous drawings, of the apparatus already shortly described by one of them in the Comptes-rendus of the Soc. de l'Industrie Minérale, for abstract of which see Vol XXXI., p. 10, Abs.

The authors give the following estimate of the cost of an installation to draw 1½ tons of coal from a depth of 22 fathoms in 151 seconds (1,600 kilogrammes from a depth of 40 m.)—

	£		Francs.
Steam engine, 20 horse-power	258	...	6,450
Bedplate for the above ...			
4 Plumber blocks ...			
2 Plumber bottoms			
5 Lubricators ...			
Shaft for friction pulleys ...			
Shaft to drive Gramme	150	...	3,750
5 Pulleys ...			
Driving belt			
Contact gear			
Pins, bolts, etc.			
Gramme machine of 8 horse-power (generator) ...	140	...	3,500
Trochometer	11·2	...	280
Galvanometer	1·8	...	45
Total at bank ...	£561	...	14,025
Gin complete	312	...	7,800
Gramme machine (motor)	140	...	3,500
Grand total	£1,013	...	25.325

To this must be added the cost of the cables—11d. per yard (1·25 fr. per m.) in dry places, 2s. 2·33d. per yard (3 fr. per m.) in wet. Also the cost of erection, both at bank and below ground.

In conclusion the authors consider that electricity may be advantageously used for transmitting power in mines principally under the following circumstances—

1.—When the mine is not very fiery.

2.—When the distance is great.

3.—When the rolleyways are very sinuous, and especially if the power has to be carried along a series of drifts and staples joining each other at right angles.

The experiments made included distances up to 3,280 yards (3 kilometres), and proved that the useful effect varied very little with the distance.

M. Marcel Despery shows that it is possible to transmit 10 horse-power 32 miles (50 kilometres) along an ordinary telegraph wire. the electro-motor having a power of about 16 horses. J. H. M.

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RESISTANCE OF TUBS TO TRACTION.

Calculs sur la résistance des wagons de mine au roulement. Par M. THIBAUT. *Bulletin, Soc. Ing. Sortis de l'École provinciale d'industrie et des Mines du Hainaut; Série 2, Tome XIII., pp.* 71–82.

M. Thibault considers that the resistances are of three kinds.

1.—The resistance due to the tub itself, viz., the friction of the axles on the cods and the wheels on the rail. This is proportional to the mass of the tub and independent of its speed.

2.—The resistance resulting from imperfections in the road. This is proportional to the mass of the tub and the square of the speed.

3.—The resistance offered by the pressure of the air upon the front of the tub. This is proportional to the velocity squared.

If then r = total resistance.
x = resistance due to 1.
a = resistance due to 2.
y = resistance due to 3.
m = mass of the tub.
v = velocity.
k, k', k'' = constants.

$$r = x + a + y = k\,m + k'\,m\,v^2 + k''\,v^2.$$

In order to determine the relative values of x, y, a, it is necessary to establish a system of three equations, which will be given by three experiments, made under different conditions of mass and velocity. This M. Thibault does, and finds that:—

$$x = \frac{V^2\,R' - V'^2\,R}{V^2 - V'^2}$$

$$a = \frac{P\,(R - R') + x\,(P' - P)}{P - P'}$$

$$y = r - x - \frac{P\,(R - R') + x\,(P' - P)}{P - P'}$$

Where R and R′ = gross resistances.
P and P′ = corresponding masses.
V and V′ = do. velocities.

PRACTICAL EXPERIMENT.

A tub weighing 244 kil. when empty, and holding 450 kil. (537 lbs. and 990 lbs. respectively), gave, at a mean speed of 3·27 m. per sec. (10·73 feet).

x = 6·836 kil.
a = 3·576 „
y = 0·498 „

R = 10·910 „ (24 lbs.)

J. H. M.

EXPLOSIVES.

The Scientific American, October 7th, 1882.—*Blue Fire as an Explosive, p.* 224.

Professor Jackson was led by an explosion of fire-works at Chester, Penn., to make some experiments on blue fire. He believes it will be found valuable as an explosive for blasting purposes, being safer and more powerful than dynamite. There are two kinds made. One is composed of chlorate of potash, three parts by weight; sulphur,

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one part; and ammonio-sulphate of copper, one part. Another and safer kind is made without sulphur, viz., ammonio-sulphate of copper, eight parts; chlorate of potash, six parts; and shellac, one part.

By means of a percussion cap, or the concussion of exploding gunpowder, it explodes readily, wet or dry, but can be dropped or struck with a hammer without danger.

New Explosive, p. 233.

Koeppel, the inventor, claims for this explosive that it is cheaper than any other, gives no injurious smoke or gases, and does not explode from concussion or friction.

It is manufactured in two kinds, of which the following is the composition:—

	Basalt, etc. No. 1.		Sandstone, etc. No. 2.	
Saltpetre	35	...	42	
Soda	19	...	22	
Refined sulphur	11	...	12·50	
Sawdust	9·50	...	19	(10?)
Chlorate of potash	9·50	...	—	
Charcoal	6	...	7	
Sulphate of soda	4·25	...	5	
Prussiate of soda	2·25	...	—	
Refined sugar...	2·25	...	—	
Picrin acid	1·25	...	1·50	
	100·00	...	109·00	(100·00)

J. H. M.

THE MARSAUT SAFETY-LAMP.

Expériences sur les Lampes de Sureté. Par M. F. CHALMETON, *Directeur de la Cie Houillère de Bessèges. Bulletin de la Société de l'Indus. Minerale, Sér.* 2, *Tome XI., 1882. pp.* 534–537, *Plate XVII.*

This article is a reprint of a letter from M. Chalmeton describing the Marsaut lamp, and asking permission of the Prefet to use it at the Bessèges Mines.

The lamp is based upon the Mueseler, but has a double gauze and a metal case round the gauze. (See Plate.)

He claims for it the following advantages:—

1.—It will not go out either when inclined or when subjected to an ascending current.

2.—It will not pass the explosion outside the lamp when subjected to a rapid current from whatever direction it may come.

3.—It will not pass the explosion outside the lamp when placed in an explosive mixture of air and coal gas.

4.—The gauze is protected from wear and dust by a metal case.

5.—The metal case being moveable, the gauze can be examined without opening the lamp.

He gives the following table of the results of his experiments:—

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Safety-Lamp Experiments.

Ordinary Flame.

Lamp.	Dates.	No. of Trials.	Explosions.	Passage of the Flame through the Diaphragm.	Totals. Trials.	Explosions.	Proportion.	Passage of the Flame through the Diaphragm.	Proportion.
							Per Cent.		Per Cent.
No. 1. Chimney without diaphragm, with metallic cuirass.	June 15	200	..	..	1,000	20	2	..	..
	,, 16	187	..	..					
	,, 17	79	5	..					
	,, 19	100	13	..					
	,, 20	100	1	..					
	,, 21	152	..	..					
	,, 22	100	..	..					
	,, 23	82	1	..					
No. 2. Large chimney, with metallic cuirass.	June 15	200	..	..	1,000	8	0·8	..	..
	,, 16	186	..	..					
	,, 17	108	..	..					
	,, 19	100	3	..					
	,, 20	105	..	..					
	,, 21	151	3	..					
	,, 22	102	..	..					
	,, 23	48	2						
No. 3. The diaphragm inclined without cuirass.	June 16	200	..	..	1,000	..	..	2	0·2
	,, 20	179	..	..					
	,, 21	200	..	..					
	,, 22	320	..	1					
	,, 23	101	..	1					
No. 4. Double gauze, with metallic cuirass.	June 15	200	..	..	1,000	..	..	..	..
	,, 16	181	..	..					
	,, 17	112	..	..					
	,, 19	105	..	..					
	,, 20	200	..	..					
	,, 21	150	..	..					
	,, 22	52	..	..					
	,, 23	..	..	..					
No. 5. Ordinary Mueseler; sundry lamps of the Belgian Government pattern.	June 15	200	4	45	1,000	12	1·2	138	13·8
	,, 16	191	..	3					
	,, 17	243	3	41					
	,, 19	103	2	25					
	,, 20	54	..	3					
	,, 21	101	3	20					
	,, 22	108	..	1					

Medium Flame.

No. 1. Chimney without diaphragm, with metallic cuirass.	June 23	100	16	..	331	41	12·4	..	..
	,, 24	52	8	..					
	,, 26	26	4	..					
	,, 27	101	12	..					
	,, 28	52	1	..					
No. 2. Large chimney, with metallic cuirass.	June 23	100	10	..	323	29	8·9	..	..
	,, 24	49	..	..					
	,, 26	23	6	..					
	,, 27	101	7	..					
	,, 28	50	6	..					
No. 3. The diaphragm inclined without cuirass.	June 23	100	..	2	1,000	..	..	5	0·5
	,, 24	98	..	..					
	,, 26	112	..	1					
	,, 27	106	..	..					
	,, 28	50	..	..					
	,, 29	150	..	..					
	,, 30	200	..	..					
	July 3	184	..	2					
No. 4. Double gauze, with metallic cuirass.	June 23	100	..	..	1,000	..	..	..	..
	,, 24	67	..	..					
	,, 26	133	..	..					
	,, 27	104	..	..					
	,, 28	61	..	..					
	,, 29	150	..	..					
	,, 30	200	..	..					
	July 3	185	..	..					
No. 5. Ordinary Mueseler; sundry lamps of the Belgian Government pattern.	June 23	100	..	12	1,000	4	0·4	139	13·9
	,, 24	89	1	11					
	,, 26	101	..	19					
	,, 27	102	..	8					
	,, 28	52	1	10					
	,, 29	150	1	22					
	,, 30	210	..	27					
	July 3	196	1	30					
	,, 4	abt. 200	4	about 120					

J. H. M.

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REPORT OF THE COMMISSION ON DYNAMITE STORES.

Rapport de la Commission des Dépôts de Dynamite. Par M. MURGUE. *Bulletin de la Société de l'Industrie Minerale; Sér.* 2, *Tome XI., 1882, pp.* 541–572.

In January, 1882, the South-Eastern District of France decided to petition Government to relax the restrictions on the storage of dynamite. A commission was appointed to study the question, and this is their first report.

The matter is classed under four heads:—

1.—Statistics of accidents.
2.—Foreign legislation.
3.—Underground magazines.
4.—Revision of the tax.

1.—STATISTICS OF ACCIDENTS.

The commission show by tables the number of persons injured by powder and by dynamite during the eleven years 1871–81, and conclude that whilst the chance of an explosion in a dynamite store is one-half of that in a gunpowder store the damage done is twice as great.

2.—FOREIGN LEGISLATION.

A short abstract of the law in Belgium, Austria, and England is given, preceded by an abstract of their own legislation on this subject.

3.—UNDERGROUND STORES.

These are of two kinds, those in the mine itself and those in special excavations removed from any workings. The first are permitted by the French, Belgian, and Austrian law, but not by the English. The advantages are:—Saving of labour, avoidance of surface liabilities, protection from frost, protection from lightning, and protection from malicious damage.

On the other hand, should the mine be fiery, great danger might accrue, and the Commission recommend that dynamite should no longer be stored in fiery mines. With reference to the second, the Commission think that no danger can accrue if they be situated deep enough, and they discuss the ordinary formula for the calculation of the depth, from which they find that 1,200 kilos. might be stored at a depth of 21·5 m.; they consider this however too shallow, and recommend an addition of 50 per cent. to the formula.

4.—REVISION OF THE TAX.

France is the only country in which dynamite is taxed. The amount (2 fr. per kilog.) is about half the price. The commission recommend that this should be reduced 50 per cent. J. H. M.

THE EFFECTIVE AREA OF AIR CURRENTS.

Über Wetterdepressionsmessungen und Bestimmung des effectiven Wetterquerschnitts. By R. HAUSSE. *Jahrbuch für das Berg-und Hüttenwesen im Königreiche Sachsen auf das Jahr* 1882, *pp.* 46–64.

The degree of efficiency of the ventilation of a mine may be expressed, according to M. Murgue, by a comparable figure of relation termed by him "orifice equivalent," or

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the equivalent opening or area in a thin partition which permits of a quantity (V) of air to flow which has a depression or water-gauge (h), calculated by the general rule affecting the efflux of air:—

$$a = \frac{V}{k \sqrt{2 g h \frac{\delta_o}{\delta}}}$$

Substituting the values for g, δ_o, δ, and k, the formula becomes

$$a = 0{\cdot}012 \frac{V}{\sqrt{h}}$$

This calculation has the objection that it is not the passage of air from a vessel into the open that has to be dealt with, but the passage of air through long tubes, and from that point of view it is difficult to say whether the above formula would hold good.

From the following it will be seen that a relation can be found that will suit both cases, and which closely resembles the above formula:—

Let H = the depression between a space devoid of air and one open to the atmosphere which = 10·308 m. water-gauge (33·82 feet).

V = velocity of air equivalent to the water-gauge H = 393 m. (1.289·4 feet).

h = the depression existing between two spaces of which one is filled with atmospheric air, and the other with air of a less density.

v_o = the theoretical velocity of the air equivalent to the depression h.

And the following proportion is established:—

$$\frac{v_o}{V} = \frac{\sqrt{h}}{\sqrt{H}}$$

$$\text{Therefore } v_o = V \frac{\sqrt{h}}{\sqrt{H}}$$

By this formula the movement of air through mines could be calculated if friction and other obstacles did not exist.

Further let—

v = the effective velocity at the termination of an air current having a water-gauge h;

F = the area of the gallery at the place of the measurement of v;

$$\text{Then } \eta = \frac{\text{Effective quantity of air.}}{\text{Theoretical quantity of air.}}$$

$$\eta = \frac{F \cdot v}{F \cdot v_o}$$

$$\eta = \frac{v}{v_o}$$

$$\eta = \frac{v}{122 \sqrt{h}} = 0{\cdot}008 \frac{v}{\sqrt{h}}$$

Further let Fi = the effective ventilating area, that is the area of a gallery through which the effective air quantity ($F \cdot v$) flows with the theoretical velocity (v_o)—

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$$Fi \cdot v_o = F \cdot v$$

$$Fi = F \frac{v}{v_o} = F \frac{v}{\frac{v}{\eta}} = \eta \cdot F$$

$$Fi = 0{\cdot}008 \cdot \frac{v}{\sqrt{h}} \cdot F = 0{\cdot}008 \frac{Q}{\sqrt{h}}$$

If the depression h is not measured at the place where the velocity is measured, but in the ventilator building, then

$$h = \phi h_1$$

$$\text{and } Fi = 0{\cdot}008 \frac{Q}{\sqrt{\phi h_1}}$$

in which Q = air quantity per second;

h_1 = the water-gauge measured at any place in the ventilator building;

ϕ = the coefficient (found by experiments) expressed by the ratio $\left(\frac{h}{h_1}\right)$ of the water-gauge h, which exists at the place where the velocity v is measured and the water-gauge h_1 in the ventilator building.

This formula for the calculation of the effective area expresses most suitably the relation existing between the volume and the depression of air currents, and can be used to compare the degree of efficiency between two or more mines with respect to their ventilation.

The place of observation of the water-gauge should either be at the point where the velocity is measured, in which case $\phi = 1 + h_1 = h$; or in the ventilator building, when the water-gauge h_1 should be reduced by multiplying it with the coefficient ϕ, which should in every case be found by experiment.

If the water-gauge is measured in the side wall of a Guibal fan, then, for the purpose of finding the average depression of the air in a gallery in the mine where the velocity is measured, the water-gauge should be placed at that distance from the circumference of the fan in a straight line towards the centre, expressed by the following rule founded on experiment:—

$s = 0{\cdot}011 \cdot r \cdot n$, where

r = the radius of the fan,

n = the revolutions per minute.

The depression can also be calculated by observing the readings of the barometer and thermometer in the mine and on the surface at the same time, and taking into account the depth between the two points of observation.

The revolutions of a ventilator are in direct proportion to the velocity measured in one and the same point in the area of a gallery, and in direct proportion to the square root of the depression.

Guibal expresses the efficiency of the ventilation of a mine by what he calls the mechanical temperament, which is the quotient of the measured volume of air (Q) squared, divided by the depression (h).

Experiments made at four Saxon mines give relations of comparison, according to the three methods of calculation, as follows:—

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Comparison of Work done by Fans in Saxony.

Colliery.	System of Engine and Fan.	Dimensions of Engine.					Dimensions of Ventilator.			Effective Work done in Horse-power.	Work Done.					Comparable Figures of Relation.		
		Diameter of Cylinder.	Stroke.	Degree of Expansion.	Revolutions per Minute.	Steam Pressure.	Diameter.	Breadth.	Revolutions per Minute.		Velocity per Second of Air in Gallery.	Area of Gallery.	Quantity of Air per Minute.	Water-gauge in Ventilator Building.	Water-gauge in Drift.	Mechanical Temperament. $a = \frac{Q^2}{h}$	Equivalent Opening of Discharge. $a = \frac{Q}{k\sqrt{h\frac{\delta_0}{\delta}}}$	Effective Ventilation Area. $F_1 = 0{\cdot}008\frac{Q}{\sqrt{\phi \cdot h_1}}$
		mm.	mm.			kg. p. 1 q.c.m.	m.	m.		h.p.	m.	q.m.	c.b.m.	mm.	mm.			
Mehner Shaft, Zaukeroda.	Direct-acting horizontal full-pressure engine, and Guibal fan.	475	820	1	60	2	7·0	1·8	60	31·0	7·9	1·8	850	39·0	37·0	5·4	0·90	0·60
		ins.	ins.			lbs. p. sq. in.	ft.	ft.			ft.	sq. ft.	cub. ft.	ins.	ins.			
	(British equivalent values)	18·7	32·3	1	...	28·4	23	5·9	...	...	25·9	19·3	30,019	1·53	1·46	...	...	...
Döhlen	Direct-acting horizontal full-pressure engine, and Guibal fan.	500	500	1	60	3	7·0	1·8	60	31·0	2·8	3·6	600	45·0	43·0	2·3	0·57	0·38
	(British equivalent values)	19·7	19·7	1	...	42·7	23	5·9	...	...	11·8	38·7	21,190	1·77	1·69	...	...	...
Königin Carola Shaft, Döhlen.	Direct-acting vertical expansive engine, and Guibal fan.	550	500	0·4	60	3·5	7·0	1·8	60	38·0	0·8	5·3	250	...	52·0	0·3	0·23	0·15
	(British equivalent values)	21·6	19·7	0·4	...	49·8	23	5·9	...	...	2·6	57·0	8,830	...	2·04	...	...	...
Albert Shaft, Niederhermsdorf.	Indirect-acting horizontal expansive engine, and combined screw and centrifugal ventilator, Pelzer patent.	500	800	0·4	60	3·5	2·2	0·8	400	51·3	7·6	2·8	1,285	...	90·0	5·1	0·86	0·57
	(British equivalent values)	19·7	31·5	0·4	...	49·8	7·2	...	...	...	24·9	30·1	45,382	...	3·54	...	...	...

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THE VENTILATION OF PRUSSIAN COLLIERIES.

Die Steinkohlenbergwerke Preussens nach der verschiedenen Art ihrer Wetterführung. A. HASSLACHER. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen im Preussischen Staate. Vol. XXX., pp.* 181–192.

The Prussian fire-damp Commission have issued ten tables embracing all the coal mines that were at work in Prussia on the 1st July, 1881, of which the following is a synopsis:—

Table 1 deals with the following information of each coal-field and Government district, the total being only here given. In 1880, 42,273,113 tons of coal were raised in the whole state of Prussia, employing on an average 155,697 men at 377 mines, of which mines 174 had proved the existence of fire-damp during the last three years, 122 had experienced explosions, and 203 been entirely free from fire-damp. Of these mines 43 were shallow, and were worked by adits, 25 were deeper and had adits and shafts, and 309 were deep and had only shafts. Natural ventilation was used at 129 mines, 29 had both natural and artificial ventilation, while 219 were altogether artificially ventilated.

Table 2 shows the division of employed above and below ground for the year 1880, the total being 155.697 persons, of which 124.790 were employed below ground, or 80·1 per cent., and 30,907 above ground, or 19·9 per cent.

As to the occurrence of fire-damp in Prussia, the line cannot be drawn so severely between mines with fire-damp and those with none, which is done in Belgium, but the Government authorities have prescribed orders to deal with those mines in which fire-damp occasionally occurs. The necessary stipulations to allow a mine to count as free from fire-damp is not laid down in the law, but is left solely to the decision of the Government mining experts and inspectors.

Table 3 deals with the production of mines with and without fire-damp. Out of the 42,273,133 tons raised, 27,631,404 were raised from 174 mines with fire-damp, or 158,801 tons per mine by 103,419 persons, or 594 per mine; while 14.641,709 tons were raised from 203 mines free from fire damp, or 72,127 tons per mine by 52,278 persons, or 258 per mine.

Table 4 shows that 65 per cent. of the production comes from mines with fire-damp, employing 66 per cent. of the total number of persons employed.

In Table 5 the number of tons raised in adit mines and shafts is shown. There were 43 adit mines, which raised 447.034 tons, or 10,396 per mine, employing 2,908 men or 68 per mine. Collieries worked by adits and shafts numbered 25, raising 1,012,540 tons, or 49,502 per mine, employing 5,115 men, or 205 per colliery. Collieries with shafts only numbered 309, raising 40,813,539 tons, or 132,083 per mine with 147,674 persons, or 478 per colliery.

Single shaft collieries only exist where great difficulties occur in sinking, such as occurrence of watery strata over the coal formation. They all occur in Westphalia, where, in the Lower Rhine district, shafts have to be sunk through a great thickness of magnesian limestone containing much water. In this district 40 mines, raising 3½ million tons per annum and employing 13,933 persons, have single shafts.

The deepest mines in each district are given in Table 6, where the Maria mine, in the Aix-la-Chapelle district, stands first in the list, having a depth of 675 metres (368 fathoms).

Table 7 shows that 129 mines are exclusively ventilated by natural means, raising 3,900,383 tons or 30,236 per mine, by 15.415 persons or 119 per mine. Twenty-nine mines have natural ventilation, but are sometimes assisted by artificial means, and raise

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3,916,730 tons or 135,060 tons per mine, by 13,179 persons or 454 per mine. Permanently artificially ventilated mines number 219, raising 34,456,000 tons or 157,333 tons per mine, by 127,103 persons or 580 per mine.

Table 8 is very elaborate, showing the system of ventilation adopted, classed into three great groups, viz.:—(1.) Mines sometimes ventilated with artificial means. (2.) Mines ventilated by artificial means only. (3) The total of one and two. Each group is subdivided, giving the number of mines with boilers in the shafts, steam pipes in upcasts, compressed air at the face, ventilating chimneys, furnaces, ventilators, and furnaces and ventilation together. The number of ventilating apparatuses are as follows:—Boilers 1, steampipes 14, compressors 23, ventilating chimneys 109, furnaces underground 121, furnaces above ground 48, mechanical ventilators 136, total 452. These figures are embodied in Table 9.

Compressed air is used to a great extent, both temporarily and permanently, in ventilating fiery mines, especially in advance headings and winning places.

Furnaces are used at a depth of 330 metres (175 fathoms). On the 1st of July, 1881, 103 Prussian mines—of which 90 contained gas—had 136 mechanical ventilators, of which a fourth served as a reserve. All of them are exhausting machines, and, as a rule, stand singly, occasionally (Saarbrücken) two are found together, so arranged, that one works behind the other.

As to their construction, Table 10 gives particulars, in which it states that 78 are Guibals, 16 Rittinger or Schiele fans, 2 Schwarz Ropf, 3 Zimmerman, 17 Fabry, 3 Kaselowsky, 3 Winter, 11 Pelzer, and 3 Körting ventilating machines.

The Pelzer screw ventilator is finding increased use in Westphalia.

C. Z. B.

MINING FATAL ACCIDENTS IN PRUSSIA, 1881.

Verunglückungen mit tödtlichem Ausgange beim Bergwerksbetriebe in Preussen im Jahre, 1881. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXX., pp.* 86–108.

	Number of Persons employed.	Number of Fatal Accidents.	Fatal Accidents per 1,000 Employed.	Number of Persons Employed per Fatal Accident.
Coal mining	162,951	507	3·111	321
Lignite „	19,959	49	2·455	407
Ore „	69,984	107	1·529	654
Other mineral mining	7,885	17	2·156	464
Total	260,779	680	2·608	383

	Tons Raised per Fatal Accident.	Value of the same. £
Coal mining	86,567	21,493
Lignite „	212,493	31,907
Ore „	43,685	31,927
Total	78,841	23,862

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Accidents in Shafts.

	Number of Persons Travelling.	Number of Fatal Accidents.	Fatal Accident per 1,000
By travelling with ladders ...	59,764	5	0·084
„ „ man engines ...	7,830	3	0·383
„ „ cage and ropes	98,328	8	0·081
Total	165,922	16	0·096

Fatal Accidents Tabulated, 1881.

Description of Accident.	Coal Mining.		Lignite Mining.		Ore Mining.		Other Mineral Mining.		Total.	
	No.	p. 1,000.	No.	p. 1,000.	No.	p. 1,000.	No.	p. 1,000.	No.	p. 1,000.
By firing	26	0 160	...	...	9	0·129	2	0·254	37	0·142
By falls—										
When kirving	13	...	...	...	...	...	...	...	13	...
In the broken	6	...	10	...	...	...	...	...	16	...
Suddenly from the top ...	176	...	12	...	47	...	7	...	242	...
Total for falls... ...	195	1·196	22	1·102	47	0·672	7	0·881	271	1·039
By inclined planes and brake staples—										
By falling	53	...	...	...	2	...	...	...	55	...
Fault of brake	4	...	...	...	...	...	...	...	4	...
Other ways	24	...	1	...	2	...	...	...	27	...
Total for planes and staples	81	0·497	1	0·050	4	0·057	...	...	86	0·321
In shafts—										
When riding	13	0·080	...	...	7	0·100	2	0·254	22	0·084
By falling	14	0·859	3	0·150	15	0·214	3	0·380	35	0·137
By things falling ...	4		1		3		2		10	
By the cage	15	0·147	2	0·150	3	0·086	...	0·254	20	0·137
Other ways	5		...		...		...		5	
Total in shafts ...	51	0·313	6	0·300	28	0·400	7	0·881	92	0·353
Haulage—										
Engine planes	...	...	...	...	...	...	...	...	...	...
Haulage by men or animals	12	...	1	...	...	...	...	...	13	...
Total for haulage ...	12	0·074	1	0·150	...	...	...	...	13	0·050
By fire-damp—										
Explosions	44	...	...	...	...	...	...	...	44	...
After-damp	17	...	...	...	...	...	...	...	17	...
Total by fire-damp ...	61	0·374	...	...	...	...	...	...	61	0·233
By black-damp	11	0·068	8	0·301	1	0·014	...	...	15	0 058
By machinery ...	9	0·055	...	...	7	0·100	...	...	16	0·061
By water	2	0·012	11	0·551	...	...	...	...	13	0·050
On the surface	41	0·252	5	0·250	5	0·071	...	...	51	0·196
Miscellaneous	18	0·110	...	...	6	0·086	1	0·127	25	0·096
Total for whole of Prussia	507	3·111	49	2·455	107	1·529	17	2·156	680	2·608
„ „ „	1880	...	...	...	...	...	...	...	650	2·597
„ „ „	1879	...	...	...	...	...	...	...	575	2·440
„ „ „	1878	...	...	...	...	...	...	...	542	2·336
Average of the years 1871–1880	...	...	...	...	...	...	...	...	582	2·465

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NON-FATAL ACCIDENTS, CAUSING INCAPABILITY TO WORK FOR ONE MONTH AND OVER.

	Passing Incapability, 1–6 Months.	Lasting Incapability.	Total.	Per 1000 Employed.
Coal mining	1,798	157	1,955	11·997
Lignite „	111	14	125	6·263
Ore „	428	12	440	6·287
Other mineral mining	25	3	28	3·551
Total ...	2,362	186	2,548	9·771
Total for 1880 ...	2,217	211	2,428	9·701

C. Z. B.

CHEMICAL ANALYSIS OF THE RETURN AIR OF COLLIERIES IN SAXONY.

Die chemische Untersuchung der bei verschiedenen Steinkohlengruben Sachsens ausziehenden Wetterströme und ihre Ergebnisse. *By* PROF. DR. CL. WINKLER. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das Jahr* 1882, *pp.* 65–84.

In 1876 Dr. A. Schondorff of Saarbrücken made some analyses of the air in the Saarbrücken mines, and was the first that introduced the term "chemical temperament" of a mine, meaning by it the average deterioration of the ventilating current per 1,000 running metres of airway by losing oxygen and taking up carbonic acid and fire-damp.

The analyses in the Saxon mines were restricted to the returns and were not so elaborate as those of Dr. Schondorff, being intended for practical men.

Samples of the air to be analysed were obtained by hanging, in a vertical position underground, tin cylinders with conical ends, made air-tight, fitted at both ends with pipes, from which India-rubber tubing with pinch cocks could be led. The vessel was filled with water before leaving the surface, and its capacity was equal to 2·2 gallons. It was then hung in position and the tube attached to the top of the vessel, fastened to two absorption tubes, of which the first was filled with glass-wool to absorb the dust, and the other with chloride-of calcium to absorb the moisture. These tubes gave the amount of dust and moisture in the air absorbed, which was done by opening both pinch cocks, the water flowing through the bottom tube sucking the air through the top one. After this had been done, the apparatus was hermetically sealed and sent off for further analysis. The amount of dust was found repeatedly to be almost *nil*. The amount of oxygen was obtained by absorption; that of nitrogen by the difference after obtaining quantities of the rest of the constituents. The amount of carbonic acid was determined by sulphate of baryta. The usual plan of determining the quantity of fire-damp in the sample could not well be applied, the quantity of fire-damp being so small, so that the plan adopted was that of freeing first the sample entirely of carbonic acid. then burning the gas and obtaining carbonic acid by means of glowing oxide of copper and treating the products of combustion with sulphate of baryta. The experiments were made at nine collieries, and it was observed that the amount of carbonic acid varied much, the source of which being the ventilating current, the burning of lights, the breathing of the men, the gas exhalation of the coal, and the gas flowing from cavities. The amount varied from 0·121 per cent. by volume to 2·716 on working days, and from 0·1168 per cent. to 2·662 per cent. by volume on Sundays. The amount of fire-damp in the return air varied from 0·01754 per cent. to 0·25576 per cent. by volume.

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on week days, and from 0·02465 per cent. to 0·12416 per cent. by volume on Sundays. The oxygen varied from 17·751 to 19·689 per cent. by volume, and the nitrogen from 75·6174 to 78·565 per cent. by volume; the moisture from 2·5254 per cent. to 4·1904 per cent. C. Z. B.

MINERAL PRODUCTION OF PRUSSIA DURING THE YEAR 1881.

Production der Bergwerke, Salinen und Hütten im Preussischen Staate im Jahre 1881. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXX., pp.* 1-85.

PRODUCTION OF COAL.

Government Districts.	No. of Mines.	Tonnage Raised.	Value. £.	Selling Price per Ton of Vend.	Average No. of Persons Employed.
Breslau	145	13,110,848	2,943,879	4·53	46,023
Halle	3	29,657	13,658	9·51	252
Dortmund	194	23,644,755	5,412,165	4·58	83,221
Bonn	31	6,608,623	2,343,152	7·11	29,745
Clausthal	13	386,662	135,844	7·03	2,938
Total	386	43,780,545	10,848,698	4·99	162,179

Of this total production, 2,920,192 tons, representing a value of £672,738, were used in colliery consumption, equal to 6·67 per cent. in tonnage and 6·20 per cent. in value.

Of the 162,179 persons employed, 128,403 were employed underground and 33,776 above ground; and of the latter, 2,848 were females, who, with the exception of 24 employed in the Aix-la-Chapelle coal-field, of the District Bonn, were employed in Silesia, District Breslau. In addition to the 386 mines at work during the year, 10 were nearly ready for winning, two were stopped owing to alterations, and two produced coal only as a by-product. The average production per man per annum was 270 tons or £66, and the average production per mine per annum was 113,421 tons or £28,105.

PRODUCTION OF LIGNITE, 1881.

Government Districts.	No. of Mines.	Tonnage Raised.	Value. £.	Selling Price per Ton of Vend.	Average No. of Persons Employed.
				s.	
Breslau	46	462,983	79.985	3·38	1.310
Halle	327	9,576,146	1,416,200	2·94	17,000
Bonn	46	223,044	34.880	3·80	916
Clausthal	27	149,980	32,384	4·38	733
Total	446	10,412,153	1,563,449	2·99	19,959

In addition to 446 mines at work, eight were in course of winning, and two were laid in. Of the 19,959 persons employed, 10,525 were employed below ground, and the rest, 9,434, above ground, of which 273 were females; 206 of which were employed in the Government district of Halle, and the rest, with the exception of two, in Breslau.

Of the total production, 907,749 tons, representing a value of £142,771, were used in colliery consumption, equal to 8·71 per cent. in tonnage and 9·13 per cent. in value. The average production per man per annum was 521 tons or £78, and the average production per mine per annum was 23,345 tons or £3,505.

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Total Fuel Production of Prussia, 1881.

Tons raised	54,192,698
Value	£12,412,147
Persons employed	182,138
Mines at work	832
Tons raised per man per annum	297
Value of same	£68
Tons raised per mine per annum	65,135
Value of same	£14.918

Production of other Minerals.

	Tons.
Bitumen—	
Asphalt	15,905
Petroleum	2,871
	18,776
Mineral salts ... (including 207,858 tons of rock salt	755,910
Ores—	
Iron	3,906,284
Zinc	659,211
Lead	148,790
Copper	515,359
Silver and gold	122
Manganese	11.085
Iron pyrites	124,925
Other ores	17,626
Total ores	5,383,402

Extraction of Salts from Aqueous Solutions.

Common salt (chloride of sodium)	247,006 tons.
Other salts	126.486 „
Total	373,492 „

Production of Metals in 1881.

Charcoal iron	31,613 tons.
Coal and coke iron	2,133,014 „
Charcoal and coal iron	8,280 „
Zinc	105,345 „
Lead (block)	81,656 „
Do. (commercial litharge)	3,203 „
Copper	15,707 „
Silver	142½ „
Gold	4·152 cwts.
Nickel	82 tons.
Sulphur	2.571 „

Manufactured Iron.

Foundry iron	380,018 tons.
Puddled iron and steel	1,159,103 „
Cast iron	864,501 „

C. Z. B.

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THE PREVENTION OF EXPLOSIONS OF FIRE-DAMP.

Rapport de M. HATON DE LA GOUPILLIÈRE, *à la Commission d'études des moyens propres à prévenir les explosions de Grisou. Soc. Ing. sortis de l'École Spéciale d'Industrie et des Mines du Hainaut*, 1880; *Série* 2, *Tome XI. annexe, pp.* 5–111.

At the meeting of the French Fire-damp Commission, held on the 24th January, 1878, it was decided to appoint a Sub-commission to draw up a preliminary report showing succinctly the present state of knowledge with reference to fire-damp, and which should serve as a point of departure for the investigations of the Commission.

This report occupies over one hundred closely printed pages, and contains a most comprehensive resumé of all that is known on the subject. The references, nearly three hundred in number, form a feature of great value. J. H. M.

AN OUTBURST OF CARBONIC ACID GAS.

Note sur l'accident du puits Fontanes des Houillères de Rochebelle (Gard). Par M. DE CASTELNAU. *Annales des Mines; Sér.* 7, *Mémoires, Tome XVIII.*, 1880, *pp.* 174–192. *One folding Plate, No. VI.*

The Rochebelle collieries (Gard, south of France) are very much troubled with carbonic acid gas, which comes off from the working face with a crackling noise like that produced by the issue of fire-damp.

At the Fontanes pit, No. 11 seam, a very violent outburst occurred on the 28th July, 1879. All the men in the seam at the time, three in number, were killed, and two others in the shaft had a narrow escape.

The volume of gas was sufficient to foul 176,583 cubic feet (5,000 cubic metres) of air in a few minutes, and issued with such force that 74½ tons (76 tonnes) of coal were blown down. It took four-and-a-half days to clear the pit of the gas. J. H. M.

ELECTRICITY.

Transmission of Power by means of an ordinary telegraph wire. Électricité—Transmission du travail à grande distance, sur une ligne télégraphique ordinaire. Note de MM. DEPREZ. *Comptes Rendus, Tome XCV., pp.* 633–634.

The telegraph line between Munich and Miesbach was used for these experiments. The distance is 35½ miles (57 kilometres). The wire galvanized iron, 0·177 inches diameter (4·5 millimetres), and the return wire the same. The total distance, therefore, was 71 miles (114 kilometres), and the resistance 950 ohms. The two Gramme machines, situated the one at Munich the other at Miesbach, were identical, and had each a resistance of 470 ohms. The total resistance of the circuit, therefore, was 1,900 ohms.

Power equal to half a horse-power (38 kilogrammes per second) was obtained at Miesbach with a velocity of 1,500 revolutions per minute, the generating machine at Munich making 2,200 revolutions, equal to 60 per cent. J. H. M.

THE CENTRAL COAL-FIELD OF BELGIUM.—CHEMICAL COMPOSITION OF THE COAL.

Étude sur le Bassin Houiller du centre (Belgique) par M. P. DUBAR, *Soc. Ing. sortis de l'École Spéciale d'Industrie et des Mines, Hainaut*, 1880; *Sér.* 2, *Tome XI., pp.* 199–229. *Four folding Plates, XIX.–XXII.*

M. Dubar has made analyses of the coal from this basin for the purpose of noting the effect of depth upon its composition. The analyses, some 300 in number, which are given, show that the seams follow the general rule, *i.e.*, the proportion of fixed carbon increases with the depth. There are, however, exceptions. J. H. M.

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THE MURE COAL-FIELD.

Notice sur les Mines d'Anthracite de la Mure. Par M. FERRAND. *Annales des Mines, Sér. 7. Mémoires, Tome XVIII.*, 1880, *pp.* 121–147. *One folding Plate, No. V.*

The author gives a description, topographical and geological, of the Mure coal-field. He also describes in detail the systems of working adopted under various conditions of thickness and inclination of the seams, concluding with the number of men employed, their wages, and the price obtained for the anthracite.

This coal-field is situated in the department of the Isère, near to Grenoble, and is about 50 square miles (128 square kilometres) in area. It contains five seams, varying in thickness from 15 inches to 40 feet (0·4—12 m.) The two highest, however (one of which is the 40 feet), are only found in a small portion of the basin.

The hands employed number 327, the hewers' wages vary from 2s. 5d. to 3s. 3d. (3 to 4 fr.) per day, and the price at the pit's mouth is 7s. 3d. (9·10 fr.) per ton.

J. H. M.

LIGNITE MINES OF THE NORTH OF BOHEMIA.

Les Lignites dans le Nord de la Bohême. Par M. CHARLES LALLEMAND. *Annales des Mines, Sér. 7. Mémoires, Tome XIX.*, 1881, *pp.* 350–493. *Six folding Plates, IV.–IX.*

The basin is bounded on the north and south by the Erzgebirge and the Mittelgebirge respectively, on the west by the Fichtelgebirge, and extends to the east as far as Böhmisch-Leipa. The length from east to west is 150 kilometres, the breadth about 8 kilometres, and the area more than 1,000 square kilometres (386 square miles).

The three principal basins are:—

1.—Elbogen, comprising the two sub-basins of Eger and Falkenau.
2.—Saatz-Teplitz, comprising the two sub-basins of Saatz and Bilin.
3.—Leitmeritz, on the right bank of the Elbe.

The formation may be divided into three stages:—

The *Lower* of middle eocene age, contains a seam from 9 to 13 feet in thickness.
The *Middle* of upper eocene age, contains some thin seams of good quality.
The *Upper* of lower miocene age, contains a seam 46 feet thick on an average, and sometimes double that thickness.

The lignite is used for domestic purposes, baking bread, lime burning, brick making, in the boilers of stationary engines, in the sugar manufactures, and even in the manufacture of Bessemer steel. About half the production is consumed in Austria; the remainder is exported, principally to Germany.

The mineral appears to have been worked since 1556, but no winding engines were used until 1856. There are now more than one hundred winding engines and sixty pumping engines.

In 1858 the gross drawings were only 225,000 tons. The production now is about 6,000,000 tons.

Several tables are given by M. Lallemand, of which the following appears the most interesting:—

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TABLE SHOWING DRAWINGS, &c.

YEARS.	WORKINGS.			WORKING COST.			SELLING PRICE PER TON.		RATIO OF PRICE.	WORKMEN EMPLOYED.			AVERAGE PRODUCTION PER MAN PER ANN.	
	Saatz-Teplitz Basin.	Elbogen Basin.	Total.	Saatz-Teplitz Basin.	Elbogen Basin.	Total.	Saatz-Teplitz Basin.	Elbogen Basin.	In Two Basins.	Saatz-Teplitz Basin.	Elbogen Basin.	Total.	Saatz-Teplitz. Basin.	Elbogen Basin.
	Tons.	Tons.	Tons.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Men.	Men.	Men.	Tons.	Tons.
1860	504,021	102,614	606,635	1,831,022	440.047	2,271,069	3·62	4·77	1·32	...	...	...	...	...
1861	599,803	115,265	715,068	2,179,102	570,680	2,749,782	3·62	4·95	1·37	...	...	...	...	...
1862	648,958	124.030	772,988	2.287.682	660,225	2,947,907	3·27	5·32	1·63	...	...	...	...	...
1863	720,374	139,369	859,743	2,638.857	682.745	3,321,602	3·67	4·90	1·34	...	...	...	...	...
1864	791,780	168,083	959,863	2,828,930	878,445	3,707,375	3·57	5·07	1·42	...	...	...	...	...
1865	768,038	177,677	945,715	2,630,455	996,417	3,626,872	3·42	5·60	1·64	3,716	...	...	207	...
1866	781,150	161,686	942,836	2,365,772	770,380	3,136,152	3·35	4·75	1·42	3,597	...	...	217	...
1867	1,039,110	200,685	1,239,795	3,393,155	945,285	4,338,440	3·27	4·70	1·44	3,805	...	...	272	...
1868	1,206,257	213,913	1,420,170	3,922,475	1,030,670	4,953.145	3·25	4·82	1·48	4.136	...	...	307	...
1869	1.426,083	224.497	1,650,580	4,372,850	1,090,417	5,463,267	3·07	4·87	1·59	4,458	1,539	5,997	320	145
1870	1,604,796	278,941	1,883,737	5,865,040	1,548,085	7,413,125	3·65	5·55	1·52	4,818	1,720	6.538	335	160
1871	2,000.317	314,609	2,314,926	9,464,060	1,981.950	11,446,010	4·72	6·30	1·33	6,444	2,383	8,827	320	133
1872	2,317,623	383.348	2,700,971	9,062,867	2,615,675	11,678,542	3·90	6·82	1·75	7,100	2,637	9,737	326	146
1873	3.023,805	502,676	3,526,481	12,854,945	3,534.230	16,389,175	4·25	7·02	1·65	9,427	2.941	12,368	320	175
1874	3,566,763	606,247	4.173,010	15,614,920	3,662.667	19,277,587	4·37	6·02	1·38	10,072	3,435	13,507	356	184
1875	3.951,953	611,731	4,563,684	15,243.722	3,208,900	18,452,622	3·85	5·25	1·36	10,495	2,347	12,842	380	260
1876	4.251,908	533,664	4,785,572	15,551,922	3,203.225	18,755,147	3·65	6·00	1·65	10,661	2,384	13,045	400	222
1877	4,411,446	552,005	4,963,451	14,728,227	3,198.092	17,926.319	3·35	5·80	1·73	10,425	2,415	12,840	422	231
1878	4.554,022	563,764	5.117,786	14,522.055	3.256,732	17,778,787	3·12	5·77	1·85	10,833	2,461	13,294	421	230
1879	5,109.363	592.292	5,701,655	14,383,907	3,150,445	17,534,352	2·85	5·32	1·87	11,235	2,443	13,678	453	242
Totals and Averages	43,277,570	6,567,096	49,844,666	155,741,965	37,425,312	193,167,277	3·59	5·53	...	7,415	2,427	9,195	337	193

J. H. M.

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STATISTICS.—COAL, IRON, &c.

Révue Économique et Statistique. Par M. Paul Trasenster. *Révue Universelle des Mines, Sér.* 2, *Tome XI.*, 1882, *pp.* 189–218, 533–541, 733–739.

These papers contain a very large quantity of statistical information, from which the following has been selected:—

(A.)—The Iron and Steel Trade.

(1.)—*Production of Cast Iron.* (*Unity* = 1,000 *metric tons; one metric ton* = 2,204 *lbs.*)

	1870.	1878.	1879.	1880.	1881.
Great Britain	6,059	6,483	6,092	7,872	8,280
United States	1,900	2,337	2.785	3,895	4,500
Germany	1,390	2,147	2,226	2,729	2,900
France	1,178	1,521	1,400	1,725	1,894
Belgium	565	519	453	608	631
Austro-Hungary	403	434	404	445	} 1,500 (?)
Russia	360	417	434	434?	
Sweden	300	340	344	405	
Other countries	150	185	185	200	
Totals	12,305	14,383	14,323	18,313	19,700

Consumption.

	1870.	1879.	1880.	1881.
Great Britain	5,375	4,860	6,070	6,480
United States	1,830	3,485	4,180	5,340
Germany	1,510	2,200	2,730	3,000
France	904	1,540	1,880	2,160
Belgium	637	627	805	805
Austro-Hungary	563	460	492	} 1,600 (?)
Russia	385	618	677	
Sweden	285	321	360	
Totals	11,489	14,111	17,194	19,385

(2.)—*Production of Wrought Iron.* (*Unity* = 1,000 *metric tons.*)

	1870.	1873.	1879.	1880.
England (?)	2,600	2.500	1,700	2,000
United States	1,170	1,666	1,856	2,115
Germany	900	1,310	1,215	1,358
France	670	940	875	985
Belgium	491	480	410	488
Austro-Hungary (?)	232	260	175	200
Russia	260	290	290	290 (?)
Sweden	214	213	236	252
Totals	6,530	7,660	6.757	7,698

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Consumption.

	1878.	1879.	1880.	1881.
England	4,055	3,310	4,160	4,310
United States ...	2,520	3,920	5,180	6,540
France	1,595	1,470	1,850	2,180
Germany	1,840	1.750	2,015	2,055
Belgium	470	340	485	460
Austro-Hungary ...	488	440	457	...
Russia	917	860	800	... 1,350
Sweden	180	175	185	...
Totals ...	12,065	12,265	15,130	16,895

(3.)—*Production of Steel Ingots.* (*Unity* = 1,000 *metric tons.*)

	1870.	1878.	1879.	1880.	1881.
England	350	1,096	1,124	1,414	1,700
United States ...	64	735	944	1,258	1,570
Germany	170	570	582	762	950
France	80	336	365	426	460
Belgium	9	115	110	120	138
Austro-Hungary...	24	152	156	160	...
Sweden	12	24	28	39	... 400 (?)
Russia	8	95	210	210 (?)..	
Totals ...	717	3,123	3,530	4,383	5,220

(B.)—The Coal Trade.

(1.)—*Production of Combustible Minerals.* (*Unity* = 1,000,000 *metric tons.*)

	1860.	1870.	1873.	1878.	1879.	1880.	1881.
Great Britain...	85·4	112·2	129·0	134·8	135·8	149·3	156·6
United States...	15·2	30·7	51·3	52·9	63·8	70·3	80·0(?)
Germany ...	12·3	34·0	46·1	50·5	53·5	59·2	61·5
France ...	8·3	13·1	17·5	16·9	17·1	19·4	19·9
Belgium ...	9 6	13·7	15·8	14·9	15·4	16·9	16·9
Austro-Hungary	3·5	8·3	11·9	13·9	14·9	16·0	16·0(?)
Totals ...	134·3	212·0	271·6	283·9	300 5	331·1	351·0
Other countries	1·7	.....	.....	9·1	.....	11·9	.....
The World	136·0	.....	.....	293·0	.....	343·0	.....

Consumption.

	1870.	1873.	1878.	1879.	1880.	1881.
Great Britain ...	100·5	116·5	119·0	119·0	130·1	136·7
United States ...	30·9	51·1	52·7	63·7	70·1	80·0 (?)
Germany	32·4	45·5	49·3	52·2	56·8	58·7
France	18·8	24·7	24·5	25·3	28·5	28·8
Belgium	10·0	11·2	10·9	11·1	12·1	12·2
Austro-Hungary...	8·3	12·0	12·6	13·9	14·6	14·6(?)
Totals ...	201·0	261·0	269·0	285·2	312·2	331·0

The consumption in tons per inhabitant in 1880 was—England 3·71, Belgium 2·26, United States 1·40, Germany 1·21, France 0·74, and Austro-Hungary 0·39.

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(2.)—*Variations in Price (Francs) per Ton.*

	1870.	1873.	1878.	1879.	1880.	1881.
Great Britain (exportation)	12·05	25·10	11·80	11·00	11·20	11·25
Germany	7·60	13·86	6·55	6·10	6·55	6·47
France	11·60	16·61	13·46	12·93	.....	.....
Belgium	10·86	21·40	9·92	9·39	10·06	.....

(3.)—*Number of Men employed, and Tons per Man per Annum.*

	Number of Men Employed.			Tons per Man per Annum.		
	1870.	1874.	1880.	1870.	1874.	1880.
Great Britain	350,894	538,828	484,933	320	261	337
Prussia	122,483	180,590	175,892	240	225	295
France	82,673	106,289	102,472	158	159	166
Belgium	91,998	109,631	102,930	149	134	164
Totals	684,043	955,338	866,227	...	...	...
United States	.....	.....	168,155	...	...	376

J. H. M.

THE ADVANCE IN MINING AND METALLURGICAL ART, SCIENCE, AND INDUSTRY SINCE 1875.

By WILLIAM P. SHINN. *Transactions of the American Institute of Mining Engineers; Vol. IX.*, 1881, *pp.* 293–299.

This is the annual address of the President of the Institute.

COAL.

During the five years, 1875 to 1880, important discoveries have been made in Utah, Colorado, Indian Territory, and New Mexico. The two last States afford good coking coal.

Comparison of the production of anthracite coal:—

	Gross Tons.
In 1871–1875	104,655,254
In 1876–1880	111,482,727
Increase	6,827,473 or 6·51 per cent.

Total production of coal in the United States in gross tons:—

	Anthracite.	Bituminous.	Total.
1870	13,985,960	15,231,668	29,217,628
1875	20,654,509	26,031,726	46,686,235
1879	27,711,250	33,665,709	61,376,959

PIG IRON.

	Gross Tons.
1871–1875	11,233,424
1876–1880	12,813,814
Increase	1,580,390 or 14·07 per cent.

IRON ORE.

	Gross Tons.
1871–1875	4,779,114
1876–1880	6,453,092
Increase	1,673,978 or 34 per cent.

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Wrought Iron.

The average consumption of fuel per ton of iron puddled has been 3,000 to 3,200 lbs. The Swindell regenerative furnace puddles a ton of iron with 1,250 lbs. of slack coal. Experiments are being made on a revolving puddler which promises even better results.

Bessemer Steel.

There has been an extraordinary increase in the production of Bessemer steel:—

	Net Tons.
1871–1875	907,060
1876–1880	3,950,954
Increase	3,043,894 or 333 per cent.

The output of ingots at some of the leading steel works during 1880:—

	Gross Tons.
Edgar Thompson	123,303
Cambria	122,143
Joliet...	116,750
Lackawanna...	105,354
North Chicago	100,178

The production of steel rails in five years was:—

	Net Tons.
1871-1875	697,142
1876–1880	3,046,584
Increase	2,349,442 or 335 per cent.

The Krupp process of washing out phosphorus is in successful operation at Springfield, Illinois, and promises well in connection with the open hearth process.

The Thomas and Gilchrist basic process is a commercial success abroad, and will soon, doubtless, be introduced into this country.

Gold.

1871-1875	$197,662,244 ...	£40,839,306
1876–1880	$196,690,603 ...	£40,638,554
Decrease	$971,641 ...	£200,752

Silver.

1871–1875	$133,607,510 ...	£27,604,857
1876–1880	$206,210,848 ...	£42,605,547
Increase	$72,603,338 ...	£15,000,688

The increase in silver is due to the great carbonate deposits of Colorado.

Petroleum.

	Barrels.
1871–1875	41,911,367
1876–1880	83,042,121
Increase	41,130,754 or nearly 100 per cent.

The following are some of the most important improvements in machinery:—

1.—The Porter-Allen high-speed engine for rolling mills.

2.—The Leavitt compound engine for pumping and hoisting.

3.—The Bulkley condenser for blast-furnace and rolling-mill engines.

4.—The Klomen eye-bar universal mill for producing weldless eye-bars of iron and steel. The only process so far used adapted to eye-bars of Bessemer steel.

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STATEMENT OF THE ANNUAL PRODUCTION OF THE LEADING MINING AND METALLURGICAL PRODUCTS DURING THE TEN YEARS, 1871-80.

Years.	Anthracite Coal.	Pig Iron.	Bessemer Steel Ingots.	Steel Rails.	Gold.		Silver.		Petroleum.	Lake Superior.	
	Gross Tons.	Gross Tons.	Net Tons.	Net Tons.	Dollars.	£	Dollars.	£	Barrels.	Ore—Tons.	Pig—Tons.
1871	17.379,355	1,707,685	48,850	38,250	35,898,000	7,416.942	20,286.000	4,191.322	5,795,000	813,379	51,225
1872	22,084.083	2,539,783	120,108	94,070	39.459,459	8.152,780	20,527,500	4.241.219	6.539.103	952,055	61,195
1873	22.880,921	2,560,962	170 652	129,015	40,456,593	8,358,800	28,252.100	5.837.210	9,879.455	1.167,379	70,507
1874	21,667,386	2,401,261	191,933	144,944	40,103,045	8,285,753	30,498.000	6.301,239	10.910,303	935.488	86,494
1875	20,643,509	2,023.733	375,517	290,863	41,745,147	8,625.030	34,043,910	7.033,865	8,787,506	910,840	81,753
5 years ...	104,655,254	11,233,424	907,060	697,142	197.662,244	40,839,306	133,607.510	27,604,857	41,911,367	4,779,141	351,174
1876	19,000,000	1,868,961	525,996	412,461	44.328,501	9.158,781	41,506,672	8,575,758	8,968,906	977,233	61.911
1877	21,323,000	2,066.594	560.587	432,169	45,300,000	9,359,462	46,075,000	9.519.628	13,135,671	960.982	29.685
1878	18,600,000	2.301,215	732,226	550.398	41,000,000	8,471.074	40.000,000	8.264,462	15,163,462	1,123.093	17,404
1879	27,711,250	2,741,853	928.972	683,964	32.539,920	6,723.123	38,623,812	7,980.126	19,741,661	1,414,182	39.583
1880	24,848,477	3,835,191	1,203.173	967.592	33.522,182	6,926,070	40,005.364	8.265,571	26,032,421	1.975.602	48.502
5 years ...	111,482,727	12,813,814	3.950,954	3,046,584	196,690,603	40,638,554	206.210,848	42,605.547	83,042.121	6,451,092	197,085

J. H. M.

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FRENCH MINERAL STATISTICS FOR 1880.

Statistique de l'Industrie Minérale de la France. Production des combustibles minéraux des fontes, fers et aciers, en 1879–80. *Annales des Mines, Sér. 7, Mémoires, Tome XIX.*, 1881, *pp.* 175–185.

This paper consists of several tables showing the production of coal, lignite, iron, and steel. Two of these are here given.

I.—Coal and Anthracite.

	Tons, 1879.	Tons, 1880.		Tons, 1879.	Tons, 1880.
Nord et Pas-de-Calais	7,449,086	8,493,904	Valenciennes	7,355,289	8,398,689
			Le Boulonais (Hardinghen)	93,817	95,215
Loire	3,147,166	3,591,699	Saint Etienne	3,104,757	3,542,129
			Sainte-Foy-l'Argentière	34,343	33,940
			Communay	3,236	12,147
			Le Roannais (Roanne)	4,770	3,453
Gard	1,665,001	2,063,947	Alais	1,634,742	2,050,756
			Le Vigan	12,243	10,430
			Aubenas	8,016	2,759
Bourgogne and Nivernais	1,320,235	1,550,464	Creusot and Blanzy	937,978	1,119,675
			Decize	189,796	217,851
			Epinac and Aubigny-la-Ronce	121,479	131,974
			Bert	37,994	49,218
			La Chapelle-Sous-Dun	26,149	23,841
			Sincey, *Forges**	6,839	7,905
Tarn and Aveyron	966,150	987,390	Aubin	658,659	666,045
			Carmaux	293,800	306,870
			Rodez	12,007	13,023
			Saint Perdoux	1,684	1,452
Bourbonnais	897,425	997,295	Commentry (and Doyet)	736,682	831,759
			Saint Eloy	127,451	130,000
			L'Aumance (Buxière-la-Grue)	33,292	34,091
			La Queune (Fins and Noyant)	..	1,445
Auvergne	262,205	231,503	Brassac	229,362	250,799
			Langeac	27,893	24,675
			Champagne and Bourg-Lastic	5,020	6,029
Hérault	231,622	227,536	Graissessac	231,622	227,536
			Montoulieu, Roujan	..	..
Ouest	181,297	177,452	Le Maine	81,976	81,579
			Basse Loire	52,942	50,513
			Vouvant and Chantonnay	39,652	40,150
			Le Cotentin (Littry, *Le Plessis*)	5,317	4,455
			Saint Pierre-la-Cour	1,510	755
Creuse and Corrèze	174,802	171,245	Ahun	168,320	164,790
			Cublac (Terrasson), Meymac, and Argentat	4,464	4,383
			Bourganeuf	2,018	2,072
Vosges Méridionales	164,143	184,546	Ronchamp	164,143	184,546
Alpes Occidentales	121,426	126,456	Le Drac (La Mure)	100,390	105,420
			Maurienne, Tarentaise, and Briançon	20,272	20,321
			Oisans (and le Graisivaudan)	644	715
			Chablais and Faucigny	120	..
Les Maures	6,287	3,890	Les Maures (Fréjus)	6,287	3,890
Pyrénées	56	..	Ibantelly, *Durban and Ségure*	56	..
Total	16,576,901	18,857,327		16,576,901	18,857,327

II.—Lignite.

Provence	474,225	495,683	Fuveau (Aix)	432,918	460,487
			Manosque	39,807	33,796
			La Cadière	1,500	1,400
Languedoc and Comtat	29,994	27,549	Bagnols, Orange, Banc Rouge, *Vagnas*	24,055	22,001
			Barjac and Célas	4,362	3,491
			Méthamis	904	1,500
			La Caunette	673	587
Vosges Méridionales	16,890	18,270	Gouhenans	10,914	10,480
Three other groups	12,969	13,283	Norroy, *Gémonval*	5,976	7,790
			7 worked, 4 *unworked*	12,969	13,283
Totals	534,078	554,785		534,078	554,785
Grand Total	17,110,979	19,412,112		17,110,979	19,412,112

* The coal-fields that have not been worked during this period are printed in Italics.

J. H. M.

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THE MINING INDUSTRIES OF ITALY.

L'Industrie Minérale en Italie depuis 1860 *jusqu'en* 1880. *Notices statistiques officielles résumées et traduites. Par* JEAN BECO *et* LÉON THONARD. *Revue Universelle des Mines, Sér.* 2, *Tome XI.*, 1882, *pp.* 160–173, 426–461, *and to be continued.*

The Italian Minister of Agriculture, Industry, and Commerce has published a volume of 400 pages, containing documents, tables, diagrams, etc., relating to the above subject.

The introduction, drawn up by M. F. Giordano, Inspector General of Mines, contains a summary of the geology of the country, the law of mines, schools, and taxes.

Several tables are given in very minute detail, from which tables a portion has been abstracted as follows:—

THE YEARLY PRODUCTION OF MINERALS.—A MEAN AVERAGE DEDUCED FROM THE YEARS 1875–79.

The Mineral.	Tons of 2,204 lbs.	Gross Value.		Men Employed.
		Fr.	£	
Iron ore	215,000	1,850,000	74,000	1,830
Manganese iron ore	11,800	138,600	5,544	200
Manganese ore	6,000	288,000	11,520	600
Copper ore	23,400	1,290,000	51,600	1,500
Zinc ore	65,200	4,238,000	169,520	2,984
Antimony	135	54,000	2,160	87
Lead ore	35,600	5,500,000	220,000	5,913
Silver ore	750	4,000,000(?)	160,000(?)	661
Tin ore	24	10,800	432	...
Iron pyrites	4,000	52,000	2,080	68
Graphite	740	20,000	800	33
Anthracite	700	21,000	840	1,460
Lignite	120,000	1,320,000	52,800	
Turf	100,000	1.400,000	56,000	2,820
Salt	321,000	2,015,000	80,600	4,404
Alum shales	5,930	...	...	200
Sulphur	282,000	30,793,000	1,231,720	21,900
Marble (Carrara, Massa, Seravezza)	132,600	12.192,000	487.680	7,760
Marble (Verona, etc.)	45.000	900,000	36,000	400
Granite	m^3 6,000	228,000	9,120	480
Building stone	...	8,000,000	320,000	9,000
Slates	20,000	360,000	14,400	350
Whetstones	...	500,000	20,000	1,020
Pumicestone, Lipari	6,000	420,000	16,800	240
Pozzuolana, Rome and Naples ...	m^3 230,000	1,035,000	41,400	220
Talc	7,300	475,500	19,020	205
Kaolin, grindstones, earths for colours, etc.	10,600	901,500	36,060	830
Asphalt	6,000	288,000	11,520	...
Petroleum	300	150,000	6,000	312
Mercury	109	654,000	26,160	330

In addition to the above, some gold, nickel, and cobalt are produced, amounting in value to £15,040. J. H. M.

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PERFORATION OF THE ALPS.—THE ST. GOTHARD TUNNEL WORKS.

Étude des Travaux Exécutés au Tunnel du Saint-Gothard. (Note Complémentaire.) *Par* M. REVAUX, *ancien élève externe de l'École des Mines; Annales des Mines, Sér.* 8. *Mémoires, Tome II.*, 1882, *pp.* 85–106.

In Tome XV. of the seventh section of the *Annales des Mines* (1879) a summary was given of the then existing state of the works at the St. Gothard Tunnel, and this notice is intended to complete the information then afforded.

The two drifts—from Goeschenen on the north, and Airolo on the south, respectively 8,440 yards (7 744·70 m.) and 7,812 yards (7,167·70 m.)—met on the 20th February, 1880, with only one foot of divergence in their lateral direction, and two inches in their level.

The work at each end was commenced in the autumn of 1872, and the work progressed at an average rate of 272 yards (250 mètres) per three months, the limit of time granted to the contractor.

After numerous experimental trials the engineers decided on adopting the borers of Ferroux and McKean, the former in practice only requiring 34 machines to 60 of the latter, with 1·5 per cent. in repairs as against 5 per cent.

A description of the latter borer, with modifications, is given, and it is illustrated on Plate I. These improvements resulted in a reduction to 40 machines, and the percentage in repairs to 2½.

The geological features are then described, and the difficulties encountered in dealing with water, the latter, however, steadily diminishing as the drifts advanced. The temperature was also found to remain pretty constant at 30° C. at the face, that at the entrances being 15° C., and the sides showing 25° C.

The cost of the tunnel complete, including lining, was £172 (4,300 francs) per mètre, as against the estimated cost of £128 (3,200 francs).

Descriptions are then given of the Fröhlich drill (Plate I., Fig. 6), and the Brandt drill (Plate II., Figs. 2–6), and the paper concludes with a comparison of the distances and facilities of the two lines of Mont Cenis and St. Gothard, "both of which are essential to English commerce and traffic."

Distance from Paris to Plaisance (the first essential point on the Brindisi and eastern route):—

	Miles.	Kilometres.
By Mont Cenis	618 ...	989
„ St. Gothard	595 ...	952

Distance from Boulogne to Plaisance:—

By Mont Cenis	777 ...	1,243
„ St. Gothard	754 ...	1,206

The interests of France are concerned in the former, and those of Belgium and Holland are affected by the latter. D. P. M.

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ON THE APPLICATION OF ARTIFICIAL VENTILATION IN THE MONT CENIS TUNNEL.

Étude sur l'Application de la Ventilation Artificielle à l'Aérage du Tunnel du Mont Cénis. Par M. F. DE KOSSUTH. *Annales des Mines, Sér. 7, Mémoires, Tome XX.*, 1881, *pp.* 285–322.

All attempts to ventilate the tunnel by natural ventilation failed, several cases of asphyxia occurred, and a constant source of danger existed. A Commission was therefore appointed, and is still at work.

The immense volume of air to be displaced is very noticeable. The total length of the tunnel is 13,000 yards (12,849 mètres) and the area 400 square feet (42 mètres). The velocity of the current to be effective should not be less than 6½ feet (2 mètres) per second; consequently 150,000 cubic feet at least should enter the tunnel per minute, this being barely sufficient to keep the air fresh.

After pointing out the difficulties presented both by the length and sectional area of the tunnel, as well as the unfavourable levels and the climatic and geographical position of the two ends, the author proceeds to estimate the large approximative discharge of noxious gases and impure air to be expected from locomotives, lights, and respiration, and then insists on the total insufficiency of the existing air pumps as ventilators.

As a summary of his calculations he gives the following as the products of combustion of the present number of trains (thirteen each way and three pilot engines) per twenty-four hours:—

	M. Cubes.
Carbonic acid gas	18,548
Carbonic oxide	9,521
Nitrogen	111,312
Steam	205,902

To dilute this enormous vitiation of the air he reiterates the necessity of no less a volume than 150,000 cubic feet per minute, and in case of a cessation of the ventilating current, he estimates a day and a half as the time when the air would become unfit for respiration.

The present appliances are described at some length, his conclusion being:—"The means adopted for partially remedying the insufficiency of the ventilation of the great tunnel of the Alps in no way suffices to create an artificial ventilation, while it considerably disturbs the natural ventilation."

He then proposes to close one end of the tunnel with movable doors, applying a shaft (or dumb drift) within them, and to place on this a centrifugal or exhausting fan, in support of which he gives instances of Guibal ventilators amply powerful and effective, and he estimates the actual horse-power required as 224. D. P. M.

PROFITS OF FRENCH COLLIERIES IN 1880.

Bénéfices des Houillères Françaises en 1880.

The French mineral statistics *(La Statistique de l'Ind. Min.)*, as published by the Minister of Public Works, give the following results:—

In 1880 there were 336 collieries at work, 209 of which gave a profit of 42,953.239 francs for a production of 17,521,774 tons, or 2·54 francs per ton.

127 worked to a loss of 5,168,648 francs for a production of 1,862,980 tons, or 2·86 per ton.

It must be borne in mind that the expenses do not include interest on capital or taxes, which will considerably reduce the profits.

The drawings, profits, losses, etc., are succinctly shown in the following table:—

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Departments.	Collieries Working to a Profit.					Collieries Working at a Loss.					All the Collieries.								
	No.	Produce in Tons of 2,204 lbs.	Profits. Francs.	Profits. Shillings.	Per Ton of 2,204 lbs. Francs.	No.	Produce in Tons of 2,204 lbs.	Profits. Francs.	Profits. Shillings.	Per Ton of 2,204 lbs. Francs.	No.	Produce in Tons of 2,204 lbs.	Profits. Francs.	Profits. Shillings.	Per Ton of 2,204 lbs. Francs.	Average Selling Price.		Average Cost.	
																Sh.	Fr.	Sh.	Fr.
Nord	11	3,585,232	3,719,001	0·824	1·03	5	116,357	616,551	4·248	5·31	16	3,701,589	3,102,450	0·664	0·83	8·896	11·12	8·232	10·29
Pas-de-Calais ..	12	4,396,847	11,037,063	2·008	2·51	8	447,476	918,370	1·640	2·05	20	4,844,323	10,118,693	1·664	2·08	9·720	12·15	8·056	10·07
Loire	35	3,154,806	11,476,963	2·904	3·63	16	400,135	760,682	1·520	1·90	51	3,554,941	10,716,828	2·408	3·01	12·176	15·22	9·768	12·21
Gard	23	1,766,894	3,595,688	1·624	2·03	7	176,947	392,441	1·768	2·21	30	1,943.841	3,203,247	1·312	1·64	9·728	12·16	8·406	10·52
Saône-et-Loire ..	9	1,232,422	3,209,447	2·080	2·60	2	49,835	168,545	1·896	2·37	11	1,282,257	3,040,902	1·896	2·37	11·024	13·78	9·128	11·41
Allier	7	728,260	3,148,936	3·456	4·32	6	154,559	217,237	1·128	1·41	13	882,819	2,931,699	2·656	3·32	10·624	13·53	8·168	10·21
Aveyron	16	485,408	835,940	1·376	1·72	7	197,336	447,485	1·816	2·27	23	682.744	388,455	0·448	0·56	9·160	11·45	8·712	10·89
Bouches-du-Rhône	6	428,793	965,341	1·792	2·24	2	28,877	255,588	7·096	8·87	8	457,670	709,753	1·240	1·55	7·852	9·84	6·632	8·29
Hérault	10	244,583	436,662	1·432	1·79	..	..	..	..	..	10	244,583	436,662	1·432	1·79	10·712	13·39	9·280	11·60
Tarn	1	306,870	1,570,620	4·088	5·11	..	..	..	..	..	1	306,870	1,570,620	4·088	5·11	12·064	15·08	7·976	9·97
Nièvre	1	207,430	772,874	2·984	3·73	..	..	..	..	..	1	207,430	772,874	2·684	3·73	11·704	14·63	8·720	10·90
Hte Saône	2	186,505	431,287	1·848	2·31	2	11,067	26,939	1·952	2·44	4	197,572	404,348	1·640	2·05	12·480	15·60	10·840	13·55
Hte Loire	3	158,936	427,009	1·104	2·68	3	72,599	263,202	2·896	3·62	6	231,535	163,807	0·560	0·70	9·696	12·12	9·136	11·42
Puy-de-Dôme ..	4	157,272	217,319	2·144	1·38	4	30,497	379,645	9·952	12·44	8	187,769	162,326	0·708	0·86	9·232	11·54	9·920	12·40
Creuse	1	138,924	466,296	2·680	3·35	2	3,219	65,028	..	..	3	142,143	401,268	2·256	2·82	10·224	12·78	7·968	9·96
Isère	10	107,463	214,005	1·600	2·	12	13,964	56,937	3·248	4·06	32	121,427	157,068	1·032	1·29	9·040	11·30	8·008	10·01
Others	58	235,129	428,788	1·436	1·82	51	100,112	599,998	4·300	6·	109	315,241	171,210	0·408	0·51	..	..	..	..
Totals	209	17,521,774	42,953,239	1·960	2·45	127	1,802,980	5,168,648	2·288	2·86	336	19,324,754	37,784,591	1·560	1·95	10·264	12·83	8·704	10·88

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In a former paper the author has shown that the 33 companies, who have leased the 41 royalties of the Nord and the Pas-de-Calais, have sunk a capital of 346 millions of francs.

This capital is equivalent to an outlay of 40 francs (32s.) per ton drawn per annum. The profits in 1880 having been 1·54 francs per ton drawn per annum show an interest of 3·8 per cent. on the capital actually sunk. In all probability the remaining French collieries have expended a similar amount of capital per ton produced; and on this assumption, the actual produce of France being 20 millions of tons, the capital sunk in coal mines will be 800 millions of francs.

These 336 collieries gave a profit in 1880 of about 38 millions of francs, which shows an interest of 4·7 per cent. on the capital sunk.

It will be seen from the above that the French mining industry by no means realises the extraordinary profits generally supposed, partly because no thought is given to the large amount of capital which must be sunk, viz., 40 francs for a ton of coal sold at 12·83 francs, and also because several mining companies are quoted which have had exceptional success, while no consideration is given to the large number of others which have collapsed entirely, or have been compelled for many years to remain inactive. J. H. M.

CLIMATIC CONDITIONS OF THE ZWICKAU COLLIERIES, SAXONY.

Untersuchungen über die Klimatischen Verhältnisse in den Steinkohlenwerken des Zwickauer Reviers. *By* Dr. Hesse *und* Herrn Menzel. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das Jahr* 1882, *pp.* 85–93, *with a text Map.*

The authors divide their work into two parts, of which the first treats of the district conditions in general, from which is gathered that the Zwickau coal-field occupies an area of 3,089 acres. The seams outcrop to the south, and dip 10 deg. towards the north, where they reach a depth of more than 765 yards at the Brückenberg Shaft, No. 1. They are covered by red sandstones, which at the Brückenberg Shaft are more than 755 yards thick. The number of seams are from ten to thirteen, of which the thickest is 26¼ feet. The seams have many bands, and produce two coals—"Pechkohle," a gas coal, and "Russkohle," a mineral wood coal of local occurrence. There are thirty-five collieries, which in 1880 produced 2,354,463 tons, employing 9,647 persons, of whom 99 were women, 191 professional men, and 90 coal-fitters and clerks. In 1880, 12 persons were killed, or 1·244 per 1,000 employed. In 1880 there were eighty-five shafts, of which the deepest is the Brückenberg Shaft, No. 1, which had a depth of 900 yards, now reduced to 820 yards. An average depth of the largest mines is from 437 to 547 yards, while that of all the shafts is 267 yards. With the exception of seven, which produce two-thirds of the output, the collieries are small, owing to the fact that there are numerous surface owners who own the coal beneath, and each works his own coal, and owing to the more or less absence of barriers, ventilation is common to many collieries. The coal-field is much cut up with faults, and great difficulty is experienced in the deep mines to keep air roads open. Guibal fans are mostly in use, which in most cases draw the air, while in a few, arrangements are made so that the air can be forced if required. The shifts are twelve hours long, from six o'clock to six o'clock, two shifts per day, the men working, after deducting meal hours and time taken in getting to and from their work, eight to nine hours. The men work often overtime, and many of them walk two hours a day to and from their homes. Sixty per cent. of them descend and ascend the shafts by cages and ropes. Most of the men belong to relief societies, of which there are nine, which are amalgamated to a certain degree.

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In the second part of the work are detailed the results of seven days' work, in which time seventeen collieries were visited and sixty-three experiments made. The observations noted were as follows:—The hour, temperature of dry thermometer, ditto of wet, relative humidity in percentage, height of the barometer, volume of air examined, amount of baryta water used, amount of oxalic acid used (from the two latter of which the volume of CO_2 was calculated by Pettenhofer's method), volume of unreduced CO_2, and volume of reduced CO_2 per unit of volume of air. The average of 57 deg. temperature, 56 deg. relative humidity or hygrometric, and 58 deg. CO_2.

		Per Cent.	Per Mill.
The average of experiments made underground	t = 23·5° C. $r.h.$ =	92·9, CO_2 =	6·06
The average of 23 experiments made at the face	t = 24·8° C. $r.h.$ =	94·1, CO_2 =	6·04
The average of experiments made in the air currents	t = 22·6° C. $r.h.$ =	92·0, CO_2 =	6·08
Intake—average	t = 17° C. $r.h.$ =	86·8, CO_2 =	1·2
Middle of air currents—average	t = 22·8° C. $r.h.$ =	88·4, CO_2 =	4·25
Return air—average	t = 24·0° C. $r.h.$ =	94·8, CO_2 =	7·06

Allowing one man to give out in 21 hours (two shifts of 10½ hours) 27 cubic feet of CO_2, one light in the same time 9·8 cubic feet, and one horse in 24 hours 76¼ cubic feet, it was found that the average of nine experiments showed that from these sources alone the air was vitiated to the extent of 0·64 per mill. (0·31 to 1·5). The hygienic state of the Zwickau mines is favourable in comparison with others. Bodemann found 12·0 per mill. CO_2 in the Oberharz mines; Angus Smith in ore mines 7·85 per mill. (between 6·0 and 22·6), and 2·4 per mill. (between 0·3 and 4·2) in coal mines; Kuborn, in the Belgium Seraing mines, 10·8, 11·7, and 1·0 per mill.; Schondorff, in the return air of the Saarbrücken mines. an increase of 5·6 to 9·6 per mill.

Other examples are given of the amount found of CO_2, temperatures, and the hygrometric conditions of several European collieries.

By 2·5 per mill. of CO_2 lights are extinguished; with 28 per mill. a match cannot be lighted, while for several minutes a difficulty of breathing will not be experienced.

C. Z. B.

IMPROVEMENTS IN MINING MACHINERY IN PRUSSIA DURING THE YEAR 1881.

Versuche und Verbesserungen bei dem Bergwerksbetriebe in Preussen während des Jahres 1881. Zeitschrift für das Berg- Hütten- und Salinen-Wesen im Preussischen Staate. Vol. XXX., pp. 230–264. *Plates IX.-XII.*

Levet's Wedge.

This wedge is either worked by compressed air or by hydraulic power. Dubois and François, in their "Bosseyeuse" used in Belgium, use compressed air. Hydraulic power is adopted in France and the Saarbrücken coal mines. When hydraulic power is used it is unlike the "Bosseyeuse," by drawing the wedge from the hole instead of driving it. It consists of a wedge, which is placed at the back of the hole, with its thin end attached to a rod which, outside the hole, forms the plunger of an hydraulic cylinder. In the hole are laid two steel cheeks through which the rod passes, and when moved forwards by hydraulic power, the wedge is drawn between the cheeks and forces the coal or stone down. The jud must be holed under. The apparatus supports itself when fixed in the hole, is very handy, weighs 110 lbs., and costs £25. The diameter of the hydraulic cylinder is 3⅛ inches.

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Mechanical Drilling Machines.

Trials with different machines, commenced in 1877, still continue at the Communion Colliery, near Rammelsberg. The machines are those of Sachs, Meyerküster, Darlington, Schramm, Fröhlich, and Neill, of which the Neill proves to be the most serviceable and useful. Many tables are given showing results as to quantity won, cost, wear and tear, wages, etc., and it appears that there is a saving equal to 2s. 3·89d. per ton of ore won in favour of machine-drilling over hand-drilling, including all costs, during the year 1880–81. The saving in favour of machine drilling for the years 1877, 1878, and 1879 was 10·39d., 1s. 0·7d., and 1s. 5·2d. per ton respectively.

Koepe System of Winding.

This system has been adopted at the Shamrock Colliery, No. 1 shaft, Westphalia. The two cylinders of the winding engine are 39·4 inches in diameter, with a 5·9 feet stroke. The drum is 26¼ feet in diameter, and is 5 feet broad. Each cage has four decks, and brings up four tons of coal. The pulleys are 20 feet in diameter, and the ropes are 1·85 inches in diameter, consisting of 114 wires 0·118 inch diameter, and 37 wires 0·098 inch diameter, of patent cast steel, weighing 38 lbs. per fathom, the breaking weight being 121 tons. The cages up to the chains are 26¼ feet high, they weigh each 2·7 tons, and 24 persons are permitted to ride in each at a time.

Co-efficient of Friction

of wire ropes, on flat turned smooth sheaves, has been found, after repeated trials, to be 0·221.

Frantz's Patent Hydraulic Keps.

These keps are in use at the Fiscal Colliery, Sulzbach, Altenwald, near Saarbrücken. The patent consists of four hydraulic plungers, two to each cage, in connection with an accumulator. These plungers are vertical, and have attached to them, at the top, horizontal levers moving on a fulcrum, the point of their attachment to the plunger. These levers are prevented from being tilted downwards in the shaft by a stop placed over the other end. The cage, when at bank, rests on the ends of two of these levers, the plungers being then at their highest point, and the communication between them and the accumulator closed. When the cage is to descend, the onsetter opens the communication tap between the plungers and the accumulator, and the weight of the cage forces the plungers down, raising the accumulator weight at the same time. This goes on until the levers disengage themselves by virtue of the descending plungers and the stationary stops, which allow the levers greater freedom. As soon as this happens, the accumulator brings the plungers back to their former position, when the tap is closed. The cage, on coming to bank, tilts the levers up till they fall clear of the cage, when they resume their horizontal position and support the cage when it is lowered on to them.

Rosenkranz's Hydraulic Kep.

This patent has been fitted up at the Westphalia Colliery, near Dortmund, and consists of a movable frame fixed below the flat-sheets, which can be moved upwards by four hydraulic plungers. To this frame are attached movable levers, which form the keps upon which the cage rests, and which, by means of a counter-balance, are kept outside the range of the cage, and which also, by means of a lever in connection with an hydraulic valve, can be moved under the cage. When the cage comes to bank, it is brought to rest just below the flat-sheets, a lever is then moved which raises the hydraulic frame, at the same time bringing the keps into the shaft, until they support the cage and bring it to the level of the flat-sheets. When the cage is to descend, the lever is moved back, which at the same time opens the hydraulic valve, releases the pressure, causing the frame to descend, and with it the levers, which fall back and the cage descends.

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Coquillon's Grisoumeter

has, after repeated experiments in the laboratory of the Fiscal Colliery, Heinitz, near Saarbrücken, been so improved that the results obtained are equal in accuracy to the Bunsen gasometric method. By it the return air at the Heinitz and Decken collieries at eight a.m., during the months of September and October, 1881, was found to contain from 0·422 to 0·568 per cent. of CO_2 and from 0·122 to 0·187 per cent. of CH_4.

Körner's Fire-damp Consuming Lamp

has proved a failure, by not being able to consume any appreciable amount when fire-damp is present in large quantities.

Safety Spirit Lamps

have been introduced on account of their greater sensitiveness in detecting fire-damp. It has been found that an oxygen flame will show a cap when fire-damp is present to the extent of only a quarter per cent.

The Manufacture of Ammonia from Coke Oven Gases.

Carvè's system is at present most extensively used at Bessèges and Gelsenkerchen, and consists in using the ovens as retorts which are heated in the flues by tarless gases. Dr. Otto's system is similar, and is used with Coppée ovens and also Lührmann's ovens. Satisfactory results are obtained by these processes if a low coking temperature (800 to 900° C.) is sufficient in the flues. If a higher temperature is required, such as is the case for Saarbrücken coals, the gases must be burnt in the ovens to obtain a high temperature, and to save the flues of the ovens from being so soon destroyed. It is questionable whether when burning tarless gases alone, which already have lost a considerable portion of their inflammable matter, a temperature of more than 1,400° C. can be obtained, which is necessary for Saarbrücken coals. At the Heinitz Colliery, in Saarbrücken, during the first half of the charge only, the oven is sealed up and the de-tarring process takes place, while in the remaining time the charge is heated by the gases of the neighbouring ovens (arranged to suit this process) which burn in the oven. The large tubular condenser, necessary to condense the tar, has been replaced by a small mechanical condenser, which separates the tar by bringing the gases together with a great velocity through small apertures. C. Z. B.

COAL CLEANING APPARATUS AT THE RHEINPREUSSEN COLLIERY, NEAR HOMBERG (RHINE).*

Die Kohlen-Aufbereitung auf der Steinkohlenzeche Rheinpreussen bei Homberg a. Rhein. By Herrn Hochstrate. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen im Preussischen Staate. Vol. XXX., pp. 279–284, with a folding Plate XIII., and Text Plate.*

The process here adopted is not entirely dry: a blast of air is only used to separate the dust from the nut coal, while the nuts themselves are treated with water for the separation of the dirt.

The rationale of the process is as follows:—First, coals over a 3·1-inch screen go as large; second, coals passing over a 2·4-inch and a 1·6-inch screen are each separately washed to take out the dirt, and are sometimes cleaned by hand; third, coals passing through a 1·6-inch screen are divided into six sorts by a revolving screen, the four smaller sizes of which, those passing 0·27, 0·47, 0·67, and 0·87-inch screens, are treated with a blast of air which separates the dust from the coarse or nut coal, which again is

* See Mr. Rathbone's paper on "The Dry or Wind Method of Cleaning Coal" at the above colliery, in the Institute Transactions, Vol. XXXI., p. 245.

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divided into fine and dust coal. The coarse or nut coal of all the six sorts is then treated with water in a peculiar way. They are brought first into quiet water, from which they pass downwards into a rising column of water, the dirt falling down against the stream and the coal rising with it. The coal is then either sold as nuts or coked. If the latter, it is drained as much as possible, dried with steam, and then ground.

Of the wind-treated coal 30 per cent. of dust is obtained. To clean 500 tons a day a 35 horse-power engine is required.

The coal for coking, after cleaning, contains 3 per cent. of water and 5·60 per cent. of ash. The nut coals contain 2·15 per cent. of water and 4·01 per cent. of ash.

The advantage of the system is that the coal is obtained in a much dryer state than when entirely treated with water, which contains as much as 27 per cent. of water, and will, after twelve days, contain as much as 18 per cent.

Experiments made at Bochum have shown that one pound of fine coal, with 18 per cent. of water, gave 9·9 per cent. of ash and evaporated 5·7 lbs. of water, while with only 3 per cent. of water the same coal gave the same amount of ash, but 8 to 8½ lbs. of water were evaporated.

The heating power of the wet coal is, therefore, at least 29 per cent. less, of which, however, 15 per cent. must be deducted on account of the less amount of coal when it has 18 per cent. of water compared with that containing only 3 per cent.

When this wet coal is coked the ovens are damaged, and an inferior quality of coke is made. The entirely wet method wastes a large amount of coal, which goes over with the dirt, more is paid in freight, and in winter a difficulty in handling occurs.

C. Z. B.

SLATE MINING AT ANGERS.

Notizen über die Dachschiefergewinnung zu Angers. By R. Nasse. *Zeitschrift für das Berg- Hütten- und Salinen-Wesen im Preussischen Staate. Vol. XXX., pp.* 223-229.

The high-dipping Silurian Slates of Angers often possess a distinct, nearly vertical, cleavage almost at right angles to the strike which is W.N.W. and E.S.E. For 5 miles W.N.W. of the Loire the slate zone, of a thickness of some 2,600 feet, is separated into four divisions, of which the upper two only, the "Veine du Nord" or "Veine des Petits Carreaux," and the "Veine du Sud" or "Veine des Grands Carreaux," are worked. The Veine du Nord, which dips north from 70 to 80 degrees, has a thill of alum slates and a 2½-feet sandstone in the roof, and has a thickness of from 530 to 590 feet, of which only 230 to 260 feet are worth winning. The Veine du Sud lies 850 feet below, dips towards the south 65 to 70 degrees, and has a working thickness of 164 to 590 feet.

The slate has, when fresh, a blue-grey colour, weathering to a yellowish grey-brown or rusty brown.

The working of these slates is said to date back to the 12th century, certainly to the 14th.

When it is worked quarry-like to the day large rectangular chambers are excavated from the surface from 60 to 70 feet long in the direction of the cleavage, and 50 feet broad. These chambers go down vertically a depth of 100 yards in good slate. A greater depth is not considered safe on account of *debris* falling from the sides of the chambers, loosened by weathering. Generally, the first 15 or 20 yards of slate from the surface is worthless. The method of working is as follows:—A long trench is cut in the slate along the middle line of the chamber in the direction of the cleavage. It is about 4 yards in depth and 1½ yards in width. From both sides of this the slate is worked off in steps towards the sides of the chambers. As soon as the two first steps

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(foncées) have advanced 6 yards, two more are started, 4 yards in height, and the trench at the same time is made deeper. Each step is occupied by from 15 to 20 workmen, and each quarry by from 80 to 90 men, of which 10 to 12 are employed in removing and lifting the slabs to the surface. The men travel up and down by ladders. The chambers in the direction of the cleavage are continuous, while on either side 10 to 15 yards are left as safety barriers.

When worked below the surface, these chambers are about 65 yards long in the direction of the cleavage, and about 55 yards wide, and some have reached a depth of 270 yards below the surface. They are reached by rectangular-sectioned shafts, which are 3¼ by 5½ yards and are in the middle of the chamber. After the shaft has reached a depth of 20 yards or so, from both sides in the direction of the cleavage as far as the chamber is to extend, a passage is driven, from which at right angles others are driven, till the whole chamber is formed with a flatly arched roof. No powder is used in this work. The chamber then progresses in a similar manner to the quarries. Between chambers working alongside a 10-yard pillar is left. The roofs in these chambers require the most careful examination, and for this purpose galleries are hung from iron rods fastened into the stone, from which two, sometimes four, men are always occupied in examining the roof with long iron bars. The men wear stout leathern hats to protect themselves from small pieces of stone. The great difficulty is the lighting of these chambers to examine the roof, which was formerly done by torches, but now by gas-light, which is being replaced by the electric light. Artificial ventilation does not exist.

Working by overhand stoping is being introduced, which will in time replace the present method, being safer, in lessening the risk from roof accidents.

The dressing of the slates has nothing special to call attention to.

In 1878, 152,351,000 pieces of ordinary slate weighing 58,370 tons, and 4,281,000 pieces of so-called English slate, weighing 5,241 tons, were dressed.

The wages of the men working in quarries is from 3 to 3½ francs per day, and underground from 3½ to 4½ and sometimes 5 francs per day. The splitting is paid by the thousand of 1,040 pieces, and a good workman can earn 3 francs per day.

The six companies working the slate have amalgamated, and the sale of the produce is effected for all by a syndicate.

PRODUCTION.

Year.	No. of Chambers (Underground and Surface).	Workmen Employed.				Horses and other Beasts of Burden.	Steam Engines.		Production of Slates.		
		In Winning.	In Dressing.	Others (including Children).	Total.		No.	H.P.	Pieces.	Total Weight.	Value.
										Tons.	Francs.
1830	9	(?)	850	(?)	1,900	480	...	...	60,000,000	(?)	1,550,000
1840	16	(?)	950	(?)	2,300	500	5	70	111,000,000	(?)	2,250,000
1850	8	(?)	800	(?)	1,550	108	22	350	104,000,000	45,000	1,800,000
1860	6	(?)	1,350	(?)	2,900	213	32	537	206,000,000	90,000	3,700,000
1877	14	594	1,275	835	2,704	187	18	292	156,000,000	63,611	4,033,524

The present yearly production of a chamber in full work amounts from thirty to fifty millions of pieces of slate. The slates are made in two sizes, one 8·26 × 3·93 to 12·59 × 8·66 inches, and the other (English slates) for export, 11·81 × 6·29 to 25·19 × 14·17 inches. The thickness of the former is 0·09 to 0·16 inches, and the latter from 0·15 to 0·24 inches. The production is more than that of half of all France. The competition with Welsh slate is keen, not only at the coast but far inland. C. Z. B.

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RESULTS OF THE EMPLOYMENT OF NEW EXPLOSIVES AT ROYAL COLLIERIES IN GERMANY.

Resultate der Anwendung neuerer Sprengmaterialien bei dem Königlichen Steinkohlenwerke. By M. GEORGI. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen auf das Jahr* 1882, *pp.* 135–144.

In general powder is used in coal and dynamite in stone. The use of No. 1 dynamite in coal is unsatisfactory, as it crushes the coal into powder round the hole, or blows out the stemming. In narrow places No. 3 coal dynamite proves more successful, as is seen from the following table:—

Explosive used.	Hewers' Shifts at 8 Hours	Distance driven per Shift.	Percentage of Round made.	Explosives.		Price per Lb.	Remarks.
				Lbs. used per Yard.	Cost per Yard.		
	Per Yard.	Feet.			Shillings.	s. d.	
Powder	4·36	0·623	38·3	2·58	0·84	3·6	
Coal dynamite ..	4·67	0·633	33·3	0·64	* 0·81 1·06	8·6 1 0½	In 1880. In 1872.

* Inclusive of detonators and fuse.

The use of dynamite in stone has reduced the cost of driving drifts one-half, sometimes two-thirds, this saving being due to a great extent to the new Tyroler boring method (Schlenkerbohren). The only disadvantage in the use of dynamite is the destruction of the roof, which is worst when driving a horizontal drift against the direction of the dip.

Prismatic gunpowder, obtained by the men in cartridges at 5·45d. per lb., in competition with ordinary powder, gave the following results:—

Explosive used.	Shifts at 8 Hours.	Hewers' Shifts at 8 Hours.	Yards driven.	Yards driven per Shift.	Per-centage of Round Coal made.	Explosives.		Remarks.
						Lbs. used per Yd.	Cost per Yd.	
		Per Yd.					Shillings.	
Ordinary Powder	84·0	2·33	28·54	0·285	20·2	2·14	0·68	3·6d. per lb.
	88·0	3·21	27·88	0·266	23·1	2·42	0·77	
Prismatic do.	89·5	2·84	31·93	0·300	27·0	2·08	0·94	5·45d. „
	147·0	2·89	51·62	0·294	24·4	0·16	0·73	

Comparing gun cotton with diatomaceous dynamite, it is found that it cannot compete with the latter.

Nobel's gelatine dynamite has won the favour of the men. It is used similarly to dynamite, while its power increases with the diameter of hole and the hardness of the stone. The explosive gases have in general the same influence on the respiratory organs as those of dynamite, and contain no diatomaceous dust. The gelatine should be exploded with double or treble power detonators, the extra cost being compensated for by increased power.

The cost of fuses and detonators is not included in these tables; the prices are those which the workman pays.

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I.—In Felsite Porphyry.

No.	Explosive used.	Area of Drift.	No. of Shifts per Yard driven.	Distance Driven.		Explosives.		Remarks.
				In Yards.	Per Shift.	Kgs. used per Yd.	Cost per Yd.	
							Shs.	
1 & 2	Diatomaceous dynamite	11·15 ft. × 5·25 ft. = 58½ sq. ft.	9·54	30·73	0·081	7·07	18·3	General wage, £2 19·63a. per yard.
3	Explosive gelatine ..	Do.	7·89	11·38	0·105	4·86	16·3	
4	Do. do. ..	Do.	7·34	9·07	0·115	5·04	17·1	
5	Diatomaceous dynamite	Parallel running drift to above	7·61	17·50	0·111	5·50	14·3	General wage, £2 10·46a. per yard.
6	Do. do.	Same size	6·42	16·95	0·131	4·68	12·0	Favoured by fissures.
7	Explosive gelatine ..	Do.	5·41	6·56	0·152	3·44	11·7	
8	Do. do. ..	Do.	7·15	17·77	0·118	4·62	15·9	
9	Gelatine dynamite ..	Do.	5·78	6·23	0·145	4·40	11·4	

II.—In Coal Measures Strata.—Sandstone and Grey Metal.

10	Diatomaceous dynamite	7·54 ft. × 4·59 ft. = 34·6 sq. ft.	4·95	16·95	0·169	2·86	7·4	General wage, 27a. 6d. per yard.
11	Gelatine dynamite ..	Do.	4·22	17·27	0·200	2·32	6·0	
12	Diatomaceous dynamite	5·9 ft. × 3·28 ft. = 19·35 sq. ft.	3·85	12·03	0·220	2·66	6·9	General wage, 22s. per yard. Horizontal drift.
13	Do. do.	Do.	2·93	14·55	0·284	2·38	6·2	
14	Gelatine dynamite ..	Do.	4·40	12·58	0·192	2·01	5·2	
15	Do. do. ..	Do.	4·77	9·84	0·175	2·29	6·0	Rising 24° in hard sandstone.
16	Explosive gelatine ..	Do.	2·93	16·40	0·284	1·56	5·3	
17	Diatomaceous dynamite	6·56 ft. × 3·94 ft. = 25·8 sq. ft.	3·12	21·33	0·266	2·75	7·1	Two parallel running air roads rising 18°. General wage, 23s. per yd.
18	Gelatine dynamite ..	Do.	3·85	18·92	0·220	2·47	6·5	
19	Diatomaceous dynamite and gun cotton equal quantities by weight	43 sq. ft.	6·05	19·90	0·138	3·39	8·8	Brake staple. General wage, 32s. per yard.
20	Gelatine dynamite ..	Do.	5·23	8·97	0·160	2·76	7·2	General wage, 33s. per yard. Brake staple.

III.—In Sandstone.

21	Diatomaceous dynamite	7·55 ft. × 4·92 ft. = 37·0 sq. ft.	5·5	8·75	0·153	2·93	7·6	Rising 45° (air drift). Wage, 25s. per yd.
22	Do., 11 lbs., and explosive gelatine, 66 lbs.	Do.	5·5	12·03	0·153	2·93	9·6	

The danger of the new explosives is if anything less than that of dynamite, for, although they freeze at the same temperature, they require double or treble detonators, therefore more mechanical effort to explode, and, on account of their gelatinous constitution, they are less liable to scatter when cut. The explosive gases of the gelatinized dynamite are lighter, therefore their use will be advantageous in places difficult to ventilate.

C. Z. B.

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MINING STATISTICS OF SPAIN FOR 1880.

Estadística Minera de España correspondiente al Año de 1880. *Revista Minera y Metalúrgica, Série C., Tomo I*, 1883, *p.* 50.

The Board of Agriculture, Industry, and Trade have lately published the statistics for 1880, furnished by the Council of the Mining Department from data supplied by the head engineers in the various mining districts. The following details and summary are extracted therefrom:—

At the close of 1880 there were 16,439 mines in Spain, 99 ore heaps (terreros), and 137 exhausted mines (escoriales), covering an area of 500,597 hectares (about 1,251,492 acres), with about 140 trial pits, occupying 3,408 hectares (8,520 acres), an increase upon 1879 of 643 mines.

Comparing the tables which are subjoined with the statistics of 1879, there was an increase of 18,110,426 metric quintals in the production of iron, or more than double; 52,639 in that of copper, and 141 in argentiferous copper; 1.172 in lead and zinc, and a considerable increase also in other minerals; while in lead, silver, antimony, and others, there was a decrease. The number of workmen killed by casualties in the mines was 87, 273 were badly hurt, and 517 slightly. The majority of fatal accidents occurred in the copper mines.

GENERAL SUMMARY.

SUBSTANCES.	Mines.	Hectares (2½ Acres).	Workmen.	Steam Engines.	Horses.	Produce.	
						Metric Quintals.	Tons.
Iron	774	11,937	14,795	4	74	36,653,380	3,606,692
Lead	907	4,196	18,969	155	4.396	2,900,470	285.406
Argentiferous lead	137	1,286	3,434	80	1,467	308,522	30,318
Silver	20	88	1,069	15	319	299.985	29,518
Gold	5	63	5	...	...	?	...
Copper	35	2,272	6,837	33	708	14,762,090	1,452,589
Do. argentiferous	2	24	38	...	...	1,010	994
Tin	1	?	4	...	...	6	½
Zinc	119	1,031	2,361	13	108	505,206	49,702
Lead and zinc ...	1	36	20	...	...	1,200	118
Quicksilver ...	12	196,418	3,045	5	140	263,362	25,914
Antimony	2	16	3	...	...	114	11
Nickel	2	32	40	...	...	60	6
Cobalt	4	35	20	...	...	1,286	124
Manganese ...	26	295	371	1	?	50,337	4,953
Common salt ...	32	400	612	2	8	172,382	16,959
Sulphate of soda ...	5	89	26	...	...	63,400	6,238
Coprolites	1	4	20	...	...	28,000	2,755
Sulphate of barytes	1	6	6	...	...	8,000	787
Alum	6	31	100	...	...	106,750	10,504
Sulphur	46	698	501	...	...	302,814	29,796
Apatite	6	62	450	6	111	247,126	24,317
Coal	409	25,515	6,811	57	1,542	8,257,902	812,584
Amber	1	4	6	...	...	8	¾
Lignite	40	2,858	350	1	20	213.379	20,996
Peat	1	23	4	...	...	2,000	196
Asphalte	2	28	8	...	...	5,839	574
Totals ...	2,597	247,447	59 905	372	8,893	.....	.....

J. H. M.

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THE VAPART PULVERIZER.

El Triturador Vapart, como máquina Separadora de Minerale. *Por* JUAN FALCO Y SANCHO. *Revista Minera y Metalúrgica, Série C., Tomo I., p.* 35.

The difficulty of separating the composite ingredients of a mineral substance has been met by experiments made by Herr Brittgenbach with Vapart's machine on specimens containing iron pyrites and blende.

When the mill revolved at a velocity of 800 revolutions per minute fragments of iron pyrites from 20 to 25 millimetres in diameter were reduced one part to powder, the other to grains of from 1 to 1½ millimetres; but reducing the velocity to 400 revolutions, similar fragments were scarcely changed in form. 800 revolutions reduced the blende, which is inferior in hardness to the pyrites, to a very fine powder; while 400 converted part into powder, and the remainder into grains of from ½ to 3 millimetres. Consequently, if a substance composed of these two bodies is subjected to the velocity of 400 revolutions per minute, the pyrites will fall unchanged, while the blende, being reduced to a very fine powder, can be easily separated by sifting. This machine can operate upon five tons an hour. The method would be of great service in phosphorite mines, as the difference which exists between the relative hardness of that mineral and of the quartz with which it is so often accompanied would render it easy to effect a sufficient separation of the two materials to prove highly remunerative, and increase considerably the wealth in phosphate of many of these mines. J. H. M.

DISTILLING APPARATUS IN USE AT THE QUICKSILVER MINE AT ALMADEN.

Una Visita al Cerco de Buitrones en Almaden. *Por* JUAN SANCHEZ Y MASSIÁ. *Revista Minera y Metalúrgica, Serie C., Tomo I.*, 1883, *p.* 60.

An important improvement has recently been introduced in the working of the quicksilver mine at Almaden, in Spain. In the furnaces hitherto in use, which had been principally copied from those of Idria, in Austria, it had been found impossible to utilize the fragments of mineral (*vaciscos*) which accumulated round them during the process of distillation, and which contained considerable quantities of the valuable metal. A new distilling apparatus has now been invented by a young engineer from the School of Mines at Madrid, Don José de Madariaga, who has introduced it at Almaden under the directions of the manager, Don Eusebio de Oyarzabal. The apparatus consists of a self-acting reverberatory furnace, one great advantage of which is that the workmen are no longer obliged to enter the furnace and encounter the danger of suffocation from the gases. No cases have been sent to the hospital where this apparatus is used. By its means the whole of the fragments are submitted to distillation, and 6 per cent. of quicksilver, which is the total contained in them, is obtained; so that from these alone which were formerly useless sufficient is gained to pay the whole expenses of the establishment. The consumption of fuel is much less than on the old system, whilst the expense of labour remains the same. The workmen having complained of injury to the sight from the emanations of the gases, they have been furnished with vizors to protect their eyes. The furnaces have been altered to burn coal instead of wood, as it is found to be more economical. A new system has also been adopted for putting the quicksilver in barrels. J. H. M.

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THE THIRION CLASSIFIER.

El Clasificador Thirion. Por ROMAN ORIOL. *Revista Minera y Metalúrgica, Série C., Tomo I.*, 1883, *p* 59. *One folding Plate.*

A detailed description, illustrated by a diagram, of a classifier introduced into a factory in Escombreras, Murcia, for the mechanical preparation of minerals, by the director of the establishment, D. Leopold Thirion. Several of these machines have been in work there since 1876 with complete success. The machine consists of a series of cones; the mineral passes in from above, and is met by a column of water rising from below, and can operate on 1,000 kilogrammes (2,204 lbs. av.) per hour, with a consumption of 14 or 15 cubic metres of water. If the quantity of water requisite should be an obstacle in localities where the supply runs short, the same water may be used over and over again, after cleansing in tanks prepared for the purpose, between each repetition. The machine is not expensive; it might be put up at a cost of from 500 to 600 francs. It can operate on all kinds of minerals. In Escombreras it is employed not only on the lead of the district, but also on the argentiferous pyrites of Ceale (Africa), on the blende and iron pyrites of Sierra de Cartagena, and on many other metalliferous substances. The same system may be applied to the cleaning of coal, with a slight alteration of the machine. J. H. M.

THE COPPER OF CHILI.

El Cobre de Chile. Revista Minera y Metalúrgica, Série C., Tomo I., 1883, *p.* 37.

The exportation of copper was in 1879 50,154, in 1880 43,653, and in 1881 38,618 metric tons (2,204 lbs.) The decrease is due to the war with Peru.

The 38,618 tons exported in 1881 were distributed as follows:—

	Tons.
England	27,647
France	7,148
Germany	1,066
Other countries	2,757
	38,618

The price in 1881 varied from £15 7s. 10d. to £18 15s. per metric ton f.o.b., dressed to a standard of 96 per cent. J. H. M.

SINKING THROUGH RUNNING SANDS.

Creusement du Puits de Quiévrechain. Par M. E. CHAVATTE. *Bulletin de la Société de l' Industrie Minérale, Sér.* 2, *Tome XI.*, 1882, *pp.* 767–799. *Two folding Plates, XVIII., XIX.*

This is an account of the sinking of a shaft through the following strata:—

	Metres.
Made ground (old brick pits filled up)	2·00
Running sands	7·90
Gravel	1·20
Incoherent marls	22·90
	34·00 (110 feet).

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The shaft was bored out by means of a tool shaped like a rake to which bags were attached. As the rake revolved the sand, etc., was stirred up by the teeth and scooped up into the bags. The tubbing followed up behind the rake, forced down by means of screw jacks.

The white chalk underlying these 34 metres of incoherent strata was bored through (111 metres) by the Kind-Chaudron process with some improvements, such as the suppression of the moss box. The finished pit was about 10 feet diameter and 80 fathoms deep. The sinking occupied 730 days. J. H. M.

A PHOTOMETER.

Dispositif pour comparer les Densités de Gaz d'éclairage. Par M. De Rey-Pailhade. *Bulletin de la Société de l'Industrie Minérale, Sér.* 2, *Tome XI.*, 1882, *pp.* 917–921. *Plate XXXIV., Fig.* 4.

The illuminating power of gas bears a fixed ratio to its density. If therefore the density can be determined at the same time the illuminating value can be determined.

M. De Rey-Pailhade's apparatus is based on the following law:—

If D_1 D_2 = the densities of two gases,

θ_1 θ_2 = the durations of flow of equal volumes of the same through an aperture in a thin plate.

Then $\frac{D_1}{D_2} = \frac{\theta_1^2}{\theta_2^2}$.

The method he adopts for noting the volume and time is as follows:—A glass vessel containing a float is filled with the gas. This vessel is closed at the top by a thin plate pierced with a small hole. Water under a known head entering at the bottom of the vessel forces the gas out through the aperture at the top. The time is noted by a chronograph, and the volume by the float rising past marks on the glass vessel. Two experiments are made; one upon air, the other upon the gas the illuminating value of which is required; and, as the density of air is known, the density of the gas, and consequently its illuminating power, can be determined. J. H. M.

THE MINERS' ANÆMIA.

Du Role des Entozoaires et en Particulier des Anchylostomes dans la Pathologie des Mineurs. Par M. le Docteur Fabre, *Médecin des Houillères de Commentry. Bulletin de la Société de l'Industrie Minérale, Sér.* 2, *Tome XI.*, 1882, *pp.* 801–826.

About three years ago the men employed at the St. Gothard's Tunnel were much troubled with anchylostomes; more recently their presence was observed in the men working at some French collieries, and it was thought that the diseases peculiar to miners might be due to these creatures, more especially the so-called *Miners' Anæmia.*

M. Fabry has interested himself in the matter. and this paper is the result of his investigations. His conclusions are that there is nothing in the conditions of a miner's life that should make him specially liable to intestinal parasites, and that anæmia, as a disease more prevalent amongst miners than amongst other persons, does not exist. J. H. M.

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THE AUBIN COAL-FIELD, ETC.

Mines de Houille et Fabrication de la Fonte dans le Bassin d'Aubin. *Par* M. COLRAT. *Bulletin de la Société de l'Industrie Minérale Sér.* 2, *Tome XI.*. 1882. *pp.* 1,043-1,080; *one folding Plate, XXXVIII.*

This paper gives an account of the mines, furnaces, etc., of the Aubin basin. and includes the position and area of the basin, its geological features, minerals, systems of working the coal, railways, blast furnaces, coke ovens, and analyses of its coal and coke.

The Aubin coal-field is situated in Aveyron, and is comprised in an isoceles triangle 8 kilometres in the base and 10 high. The total surface area is about 4.000 hectares (15½ square miles), and that of the seams already known 2,200 hectares.

The coal royalties are leased by five companies.

The thickest seams of coal are found in the centre of the basin, viz , at Decazeville and Combes, where the total thickness of coal varies from 70 to 80 metres (230 to 260 feet). Towards the east and west it diminishes, being at Palayret, Firmy, and Aubin only 12 to 15 metres (40 to 60 feet). Towards the north and south it also thins, being 20 metres (65 feet) at Campagnac, 10 metres (32 feet) at Ruhl. and 8 metres (26 feet) near Bouquiès. Some of the seams are very irregular in thickness, the *grande couche* of Bourran thinning out towards the east from 70 metres to 3 (230 feet to 10).

The present systems of working are:—

1.—Quarrying.
2.—Horizontal system with stowage.
3.—Vertical system with stowage.

1.—The greater part of the thick seams near the centre of the basin (Combes, Lavayasse, etc.) can be worked in this way. The Lavayasse coal quarry,* begun in 1860, is considered as the type of this system.

2.—This method also is employed in working the thick seams in the centre of the basin. A level, about 8 feet square, is driven in the middle of the seam in a direction at right angles to the dip, from which juds are set away right and left every 22 yards to the roof and floor respectively. A horizontal slice of coal being extracted, the goaf is stowed, and a new level driven as before, but upon the stowage.

3.—This system is principally used on the east side, where the seams are thinner, much faulted, and very inflammable. It has been often described, and has not been altered for the last twenty years. J. H. M.

THE BESSÈGES COLLIERIES.

Installations de la Compagnie Houillère de Bessèges. *Par* M. J.-B. MARSAUT. *Bulletin de la Société de l'Industrie Minérale, Sér.* 2. *Tome XI*, 1882, *pp.* 861-878; 14 *folding Plates, XX.-XXXIII.*

The author gives an account of the arrangements—more especially the mechanical arrangements—at these mines. The plates, however, are the most interesting part of the paper, a great many of the more important colliery appliances being illustrated.

J. H. M.

* For a description and plate, see "Cours d'Exploitation des Mines," par A. Burat, p. 14.

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EXPERIMENTAL NOTES ON THE OTTO GAS ENGINE.

Étude Expérimentale d'une Machine à Gaz, du système Otto, de Cologne. ***Par*** FRANÇOIS SINIGAGLIA, *Ingénieur, etc., à l'École Royale des Ingénieurs à Rome. Revue Universelle des Mines, Sér. 2, Tome X.*, 1881, *pp.* 348–379.

After describing the means by which the testing apparatus was accurately gauged and proved, the actual admission and work of the gas is described, and the different velocities due to the inflammation of the mixture of air and gas by the burner diagrams are given, and from them calculations made of useful effect. In addition to these the temperatures are quoted, and the actual results obtained described at some length. The tables, pp. 376 to 379, are well worthy of study. Summary:—0·734 indicated horse-power, 0·451 effective horse-power; gas alone costing 3·60 francs per day of 10 hours, or 3½d. per hour for ¾ horse-power. D. P. M.

THE COMBEREDONDE VENTILATOR.

Note sur le Ventilateur de Comberedonde. ***Par*** MM. P. MIRC, *Directeur des Mines de Cessous et Comberedonde. Bulletin de la Société de l'Industrie Minérale, Sér.* 2, *Tome X.*, 1881, *pp.* 109–145.

The paper describes the Guibal ventilator which was erected at Comberedonde on the basis of the calculations of M. Murgue. The following rough and very brief summary will only serve as a faint outline of this very interesting paper:—

Output, 400 to 500 tons of coals per day; volume of air required, 50,000 cubic feet per minute; estimated water-gauge (by Devillez's theory) for above volume, 3 inches nearly (70 millimetres); fan erected to perform this duty, Guibal, of 30 feet in diameter by 6 feet 6 inches wide, with duplicate engines each 20 inches by 20 inches.

This fan varies considerably from the Guibal adopted in England, and is illustrated by several drawings appended.

The boilers were fired with refuse coal, yielding 50 per cent. of ashes, absolutely worthless for sale, and the fires could only be kept up by connecting the flues with the main drift of fan, thus dispensing with a boiler chimney.

The steam jacketing of the cylinders and variable expansion gear are fully described, but the results obtained by these adjuncts are so trivial as to prevent the recommendation of similar complications in other cases.

No vibration was noticeable on the main shaft owing to the counter bearings.

The cost is given as:—

			Francs.
1.—Earthwork and excavations			1,998·10
2.—Masonry—Fan and drifts	9,348·15		
Boilers and seating	6,080·25		
		—	15,428·40
3.—Machines—Engines, fan, etc.	24,296·55		
Steam pipes, etc.	405·65		
		—	24,702·20
4.—Boilers, pipes, and shed			17,273·60
Total			59,402·30
Say			£2,376

D. P. M

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ON THE COAL AND BITUMEN DEPOSITS OF TRINIDAD.

Étude sur les Gisements de Charbon et de Bitume de la Trinidad. *Par* M. CUMENGE, *Ingénieur des Mines.* *Annales des Mines, Sér.* 8, *Tome II.*, 1882, *pp.* 137-183.

The author, after describing the situation and geographical configuration of the island, gives details of the population, which is recruited by an annual importation of Coolies, who, with the native Indians, furnish a steady and useful set of workers. It has increased from 17,000 in 1797 to 125,000 at the present day, while the exports and produce have augmented in a still larger ratio. The topography and geology are then given in detail, and the tertiary formations, in which the coal and bitumen are found, are enumerated and classified.

The combustible matters of commercial importance are :—

1.—COAL.

(A)—*Lignites of the Eastern Division.*—These are found at an angle of 45 degrees dip to the north, and vary in some thirty seams from a few inches to 3 feet. Specific gravity 1·2 to 1·4. Brownish or reddish ash 2½ to 5 per cent. Contain pyrites from ½ to 5 per cent. Carbon 40 to 50 per cent. The difficulty of working and the depth of these seams have hitherto precluded their being worked.

(B)—*Williamsville Coal.*—This has only been worked for a small sugar refinery, and is of no importance.

(C)—*Piparo Coal.*—Discovered about two years since. This coal is good and marketable, being nearly equal to Newcastle coal, and containing 57·8 per cent. of carbon, 38·6 per cent. of volatile matter, and 3·6 per cent. of ash.

2.—BITUMEN.

(A)—*Lac de la Braie.*—This is distinguished from asphalte (such as Val de Travers) by its deposition in sands or other tertiary beds in concentrated masses, which the author estimates as a total deposit of some 3,000,000 tons.

This deposit is leased by the English Government to a company on a term having yet forty years unexpired. The annual output is 11,000 tons of rough and 5,000 tons of prepared bitumen, the price of the former being 20s. and the latter 48s. per ton f.o.b.

(B)—*Guaracaro (Glance-pitch).*—Specific gravity 1·33. Solid and hard under ordinary temperatures, and jet black with conchoidal fracture.

The following table gives comparative values:—

Name.	Fixed Carbon.	Volatile Matters.	Ash.
Lac de la Braie	3	50·00	47·00
Do. from plain	18	28·00	34·00
Do. fluid from centre of the lake ..	5	62·00	33·00
Do. purified (refined)	5	58·00	37·00
Guaracaro (Glance-pitch)	7	83·60	9·40

D. P. M.

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NOTES ON A ROTARY BORER.

Note sur une Perforatrice a Rodage. Par EGYDE JAROLIMEK, *Conseiller Supérieur des Mines, etc., à Vienne. Revue Universelle des Mines, Sér. 2, Tome X.*, 1881, *pp.* 60–94.

The principles of a rotary as compared with a percussive drill have been described in so many technical works, that the author confines himself to the general result of ordinary percussive hand machines as being only 4·4 per cent. of useful effect. 95·6 per cent. being lost as follows :—

	Per Cent.
Replacing hammer in position for striking	50·0
Mean of inertia and rigidity of tools	21·8
Wear and tear of tools	5·1
Resistance of small particles in hole	1·7
Defective and missed strokes	17·0
	95·6

Mechanical percussive borers, either steam or compressed air, appear as rather inferior even to these in their results, the best only giving 10 per cent. on the machine and perhaps as little as 1 per cent. on the rock, but they have the advantage of giving deeper holes of larger diameter.

Rotary borers, or "drills" properly so called, are divided into two classes :—(*a*) those wearing out (*usant*) the stone, such as the *Diamond* machines; and (*b*) those crushing (*écrasant*) the rock, or reducing it into small fragments, this class being again divided into "mechanical screwing" and "direct hydraulic pressure."

The system described at length in the paper is one in which the drilling is supplemented by pushing forward the tool by a differential screw, and the author summarises the advantages as follows :—

1.—Less expenditure of power.
2.—Direct advantage easily obtained from any available water column, such as rising mains, etc.
3.—Simplicity in construction and small cost in repairs and maintenance.
4.—Increased effect by greater speed of chisel and diminished travel of differential screw.

D. P. M.

WENGER'S COMPRESSED AIR BRAKE.

Rapport de la Commission chargée d'examiner le frein a air comprimé de M. Wenger. Par M. VICAIRE, *Ingénieur en Chef des Mines. Annales des Mines, Sér.* 8, *Tome II.*, 1882, *pp.* 115–135, *Plate III., Figs.* 4–12.

The results obtained by this brake are very analogous to those afforded in this country by the Westinghouse and Smith brakes, and as the report of the Commission appointed to examine its working is not to be considered as conclusive, the subject need not be detailed in this abstract. The Commission, however, is favourably disposed towards it, and the rapidity of action, as shown in the accompanying tables, and the simplicity of construction, argue well for a further account of the system.

D. P. M.

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ON A NEW SAFETY-VALVE.

Note sur une soupape de sureté imaginée par M. Codron, de Lille. *Par* M. OLRY, *Ingénieur des Mines.* *Annales des Mines, Sér.* 8. *Tome II.*, 1882, *pp.* 107–114, *Plate III., Fig.* 5.

By the law (décret du 25 Janvier, 1865) every boiler in France has to be provided with a safety-valve of sufficient area to allow of the escape of steam under the registered pressure, whatever might be the intensity of the firing.

The author, after calculating the actual room afforded by existing systems, shows the small annular lift of the valve is insufficient, and has actually often the effect of diminishing the pressure at the valve, and thus closing instead of opening it.

The new enactment (30th April, 1880) provides that when a safety-valve is raised it shall at once discharge all the steam which the firing is capable of producing. This led to the idea of introducing automatic or artificial raising of the valve in order to effect this escape of steam without diminishing the working pressure of the boiler. Several inventions were in consequence introduced, amongst which that of Adams, of Manchester, is cited, and then a full description of the Codron valve is given (Plate III., Fig. 5), results of experiments showing that the valve by its automatic action reduced the pressure from a point to which it was artifically raised to its authorised pressure, keeping the boiler constantly at the normal figure whatever might be the excess of firing. D. P. M.

A NEW METHOD OF MEASURING THE DEPTHS OF WORKING SHAFTS.

Ein neues Verfahren zur Messung von Schachttiefen. *By* HERR GRÄFE. *Berg- und Huettenmœnnische Zeitung, Vol. XLII.*, 1883, *p.* 4, *Plate I.*

The plan is simple, and consists in measuring the shaft by means of a steel measuring tape of a sufficient weight to keep it stretched when in use. Two men stand on the cage cover, while a third sits in a seat fastened to the rope about 10 metres above the cage. The tape is 10 metres in length. The cage starts from a mark at bank, and is lowered until the man on the seat comes opposite the mark, against which he puts the tape, whilst the man on the cage marks the other end, the second man on the cage being employed to signal to the engineman. This goes on until the whole depth is traversed.

As to its accuracy the following examples testify:—

Leopoldshall shaft measured in six hours three times—

	Depth in Metres.
First time	334·757
Second time	334·758
Third time	334·758

Von der Heydt Shaft, with seven landing depths, taken four times in six hours—

	Depth in Metres.
First time	353·715
Second time	353·713
Third time	353·717
Fourth time	353·714

C. Z. B.

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FREUDENBERG'S SMOKE CONDENSER FOR LEAD AND SILVER SMELTING WORKS.

Freudenberg's Rauchcondensationsvorrichtungen zur Emser Blei- und Silberhütte. Berg- und Huettenmænnische Zeitung, Vol. XLII., 1883, *p.* 67, *Plate II., Figs.* 13–14.

The amount of soot won in a condenser is proportional to the surface of the condenser over or through which the smoke passes. It is therefore of importance to increase the flue area as much as possible, care being taken at the same time not to obstruct the draught to an objectionable extent. Freudenberg's condenser consists in hanging thin iron plates in the flue edgeways to the current, so as not to hinder the draught much, and so obtain in a 1 metre length of flue, having a rubbing surface of 8·22 square metres, a surface eight times as great, being equal to 65 square metres. During the years 1874–75, 8·39 kilogrammes of lead were obtained per 1,000 kilogrammes of ore treated in a flue whose surface was 2,385·47 square metres; during the years 1880–81, with an increased surface of flue by the Freudenberg arrangement, amounting in all to 23,791·12 square metres, 84·80 kilogrammes of lead dust were obtained. At the Emser Smelting Works the condenser has been made on a large scale. The total length of the flue is 2,271·48 metres; greatest area, 4·512 square metres; height of chimney, 45 metres, of which the lower diameter inside is 2·47 metres, upper 1·80 metres; inner surface of flues 18,060·01 square metres; surface area of iron sheets hung up to October 1st, 1881, 11,416·25 square metres; area of sheets hung since, 13,055·35 square metres; total surface in rubbing area, 42,531·61 square metres; average cost of 1 square metre surface of built flue, 11·71s.; cost of 1 square metre of hung sheets, 0·71s.; cost of the whole condenser, £13,663. In seven periods of 200 days the soot amounted to 632,731 kilogrammes, of which 56·9 per cent. was lead (including silver), valued at £4,429; therefore, in 350 days, the figures would be 1,107,279 kilogrammes, equal in value to £7,751.

The great saving of flues with iron sheets over brick flues is visible from the following figures:—The sheets now hung cost £905; the same surface area in brick flues would have cost almost sixteen times as much, or £14,328, a saving of £13,423.

C. Z. B.

MINING, SMELTING, AND SALT PRODUCTION OF BAVARIA IN THE YEAR 1881.

Bergwerks,- Hütten- und Salinenbetrieb Bayerns im Jahre 1881. *Wochenschrift des Vereines Deutscher Ingenieure,* 1883, *p.* 18.

1.—Minerals and Ores.

	Metric Tons.*	Value. £	s.	d.
Coal	494,287·300	215,215	16	0
Lignite	16,624·000	3,125	2	0
Iron ore	75,580·700	18,038	16	0
Zinc and lead ore... ...	766·934	4,016	8	0
Copper ore	2·850	67	14	0
Antimony ore	11·715	185	2	0
Manganese ore	70·000	14	0	0
Iron pyrites	988·000	592	8	0
Rock salt	860·000	1,090	18	0

* 1 metric ton = 0·984 English tons.

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2.—Other Minerals.

	Metric Tons.	Value. £	s.	d.
Graphite	1,551·200	6,788	12	0
Coloured earth	3,740·000	6,101	5	0
Porcelain clay	11,023·000	6,640	6	0
Fireclay	59,416·700	26,488	1	0
Steatite	652·000	1,753	18	0
Fluor spar	1,166·000	612	3	0
Heavy barytes	1,477·000	591	12	0
Felspar	426·003	213	0	0
Slates	1,093·000	1,378	13	0
Cement marl	66,522·800	9,678	8	0
Emery	71·000	139	6	0
Gypsum	45,228·918	5,028	6	0
Limestone...	120,931·300	5,687	3	0
Sandstone...	12,295·180	2,018	6	0
Grindstones	169·950	4.068	15	0
Basalt	70,868·000	16,905	7	0
Granite	142,991·000	73,554	13	0
Melaphyre	69,132·000	18,700	4	0
Flagstones	32,881·000	26.427	18	0
Lithograph stones ...	7,925·000	55,475	0	0
Quartz sand	31,330·000	6,463	0	0
Wash gold	0·1248 kg.	16	6	0

3.—Salt.

Rock salt	44,384·019	98,050	9	0

4.—Smelting Works.

Pig iron	37,297·832	96,007	0	0
Castings from ores ...	1,847·771	16,210	6	0
Do. pig iron ...	28,928·224	285,012	5	0
Bar iron	61,811·560	451,298	6	0
Plate iron	3,651·688	41,711	9	0
Wire	3,355·370	28,994	6	0
Steel	2,112·600	15,912	7	0
Vitriol	477·800	3,480	1	0
Alum	544·058	4,225	5	0
Aluminium sulphate ..	3,918·478	24,850	0	0
Sulphates	1,611·615	6,200	0	0

At the 71 mines working the minerals and ores under (1) there were 3,851 persons employed, of which 3,035 were employed in coal mining. At the six salt works, 304 persons were employed, and at the smelting works 4.859 persons. together 9,014 persons. The number of persons employed under (2) is not given. C. Z. B.

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NEW GERMAN PETROLEUM WELLS.

Neue Petroleumbohrungen in Deutschland. *By* DR. KOLLMANN. *Wochenschrift des Vereines Deutscher Ingenieure*, 1883, *pp.* 20, 21.

The author asserts that with a large capital the petroleum industry of Germany would become very important. The different qualities of the Oelheim oil and the Bavarian are gone into. With regard to the Tegernsee petroleum in Bavaria, it was discovered so far back as 1450, the well from which it flowed was supposed to be holy and its water useful as a healing agent, and a chapel exists close to the spot. All about the neighbourhood the oil exists at an inconsiderable depth, and is now being worked. As the quantity is unknown, the only thing that remains to speak of is its quality. The Oelheim raw oil from small depths has a specific gravity of 0·850, which only gives 18 per cent. of lighting oil. The Tegernsee oil from a shallow depth has a specific gravity of 0·811, which burns at once, when touched with a light, with a long flame with little residue. The oil is of a brown colour, with a green shimmer or lustre, and has a strong odour owing to volatile constituents. Unlike the Oelheim oil, it leaves a short thread behind when passed through the fingers. The oil boils at a temperature of 126° C. (258·8° F.), but the boiling point does not remain the same, but rises gradually. When the temperature reaches 180° C.. 14 per cent. of the oil distils as a clear colourless fluid of a specific gravity of 0·731, which is easily ignited. This is naphtha, an exceedingly valuable product. At a temperature of 320° C. 39 per cent. of the oil distils over as a weak yellow fluid of a specific gravity of 0·786, which is not easily ignited, and which can be used for burning. With a higher temperature 16 per cent. of the oil becomes a thick reddish yellow grease oil of a specific gravity of 0·834, and then 25 per cent. of a paraffin containing oil, which solidifies in the cold, and from which grease and paraffin can easily be procured. The Tegernsee oil, therefore, contains as much naphtha and paraffin as the Pennsylvanian oil. From appearance it seems that, with a different method of distillation, more than 39 per cent. of lighting oil could be obtained. It is more easily distilled than the Oelheim oil. and is therefore to be preferred. The present winning consists of a shaft 20 yards deep, in which the oil swims in water, which is sweet, while in Oelheim the water is salt. A great deal of gas comes away. Geologically it is of interest to state that the oil exists about 80 metres above the level of the lake Tegern, and 840 metres above the level of the sea. The strata from which the oil runs lies above the chalk greensand, and consists of marl and sandstone. Gümbel and V. Decken suppose. however, that the oil comes from greater depths from the nummulitic formation. C. Z. B.

VIBRATIONS OF STRATA IN MINES.

Ueber Gesteinschwingungen in der Grube. *By* HERRN FR. SCHELL. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXXI. B, pp.* 31–33, *Text Plate.*

The author refers to his paper upon this subject in Vol. XXVIII. B, page 340. of the above-named periodical. Then. having pointed out that observations hitherto recorded have been upon sound carried through strata in a horizontal direction. and having given examples, he mentions a case of sound having been carried vertically 164 metres (179 yards) at Grund. Here the noise made by the stamps at the Hulfegottes Shaft was heard in a drift below. The drift was not situated vertically below the stamps, and the total distance therefore was rather more than 164 metres, viz., 174 metres (190 yards). C. Z. B.

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THE MINERAL AND SMELTING WORKS PRODUCTION OF THE GERMAN EMPIRE DURING THE YEAR 1881.

Production der Bergwerke, Salinen und Hütten im Deutschen Reiche und in Luxemburg für das Jahr 1881. *Glückauf*, No. 1, 1883.

	Production in Metric Tons (2,204 lbs.)	Percentage of Increase on 1880.	Percentage of Decrease on 1880.
Coal	48,688,161	3·7	—
Lignite	12,852,324	5·8	—
Graphite	1,511	4·2	—
Asphaltum	42,330	—	15·5
Petroleum	4,108	213·8	—
Rock salt	311,907	14·6	—
Kainite	160,538	16·8	—
Other potash salts	745,353	41·1	—
Iron ore	7,573,772	4·6	—
Zinc ore	659,531	4·2	—
Lead ore	164,771	3·2	—
Copper ore	523,697	8·9	—
Silver and gold ore	26,787	30·2	—
Tin ore	164	—	18·0
Manganese ore	13,642	14 7	—
Iron pyrites	125,057	11·4	—
Salt from salt works	456,958	1·5	—
Chloride of potash	113,168	35·3	—
Chloride of magnesium	11,070	—	1·3
Glauber salt	49,062	5·3	—
Sulphate of potassium	13,280	25·3	—
Sulphate of magnesium	25,908	26·4	—
Sulphate of alumina	12,837	0·1	—
Alum	5,068	7·6	—
Pig iron	2,914,009	6·8	—
Zinc	105,478	5·9	—
Lead (block lead)	86,729	0·9	—
Litharge	4,514	15·1	—
Copper	14,802	7·0	—
Silver	186,990 kg.	0·5	—
Gold	381 „	—	17·7
Nickel	135 tons	—	6·9
Tin	103 „	—	1·0
Bismuth	56	21·7	—
Arsenic	1.237	9·4	—
Pig iron for foundry use	246,971	16·8	—
Pig iron for ingot iron	886,750	21·2	—
Pig iron for wrought iron and steel	1,728,952	—	0·2
Castings (first melting)	34,642	—	6·1
Scrap iron	16,694	1·5	—
Cast iron (second melting)	560,222	8·8	—
Worked iron (wrought iron and steel)	1,421,792	4·7	—
Ingot iron. including crucible steel	897,425	35·9	—

The above table in the original gives besides the total and tonnage value. Other tables show the production subdivided into the different States comprising the German Empire, going back as far as 1872. C. Z. B.

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THE PRODUCTION OF LEAD IN 1881.

Bleiproduction der Welt im Jahre 1881. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen, Vol. XXXI., p.* 57.

		Metric Tons.
Spain	about	120,000
Germany	„	90,000
Great Britain	„	67,000
France	„	15,000
Italy	„	10,000
Greece	„	9,000
Belgium	„	8,000
Austria	„	6,000
Russia	„	1,500
Europe	„	326,500

The United States produces 110,000 tons.

As the production of Mexico, South America, Canada, Australia, etc., is comparatively small, the world's production can be safely estimated at 450,000 tons of lead. China and Japan are not taken into account, owing to want of trustworthy information.

C. Z. B.

MÜESELER SAFETY-LAMP WITH AN ELECTRICAL BELL.

Müeseler's Sicherheitslampe mit elektrischem Läutewerk. Berg- und Huettenmœnnische Zeitung, Part 7, 1883, *p.* 68, *Plate II., Figs.* 15-17.

Lamps have already been made to detect ½ per cent. of fire-damp in the air, viz., that of Mallard and Le Chatelier, Cosset-Dubrulle's indicator, and the lamp of Pieler, in which a spirit flame is used. Somzée has made lamps in Paris so constructed that a rise of temperature in the lamp affects by unequal expansion two metals, so arranged that when heated they close an electrical circuit and ring a bell. The expansive pieces are made like rods, spirals, or oval tubes, made of steel (co-efficient of expansion = 0·00001079) and zinc (co-efficient of expansion = 0·00000331) which are soldered together with tin.

In the Müeseler lamp the arrangement is fixed between the outer gauze and the chimney, and insulated from the chimney by means of a wire or glass cylinder next to the chimney. The bell arrangement with the galvanic element is fixed in the bottom of the lamp. The outer gauze prevents the firing of gas by the spark resulting from contact of the arrangement, and the metal spiral, rod, or oval tube is so fixed by experiment that when contact occurs and the bell rings the percentage of gas in the air is known. All the contact surfaces are platinized, yet frequent cleaning is necessary to keep them in good order.

C. Z. B.

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THE VENTILATION OF THE ST. LOUIS TUNNEL, NORTH AMERICA.

Die Ventilation des Tunnels bei St. Louis, Nordamerika. Wochenschrift des Vereines Deutscher Ingenieure, 1883, *p.* 27.

The tunnel in its course has a right angle bend, is 1,527 metres (1,770 yards) long, and has inequalities of level amounting to from 1 in 300 to 1 in 1·75, with a radius of 152 metres. On account of these conditions the 172 trains which pass a day must go through with full steam, causing heavy firing (coal) and a great deal of smoke which the four ventilating shafts cannot disperse. Coke has been tried, but with no success. Now a ventilator has been constructed on the Fourneyrou turbine type, which is 4·57 metres (14¾ feet) in diameter and 2·75 metres (8·86 feet) wide, with 32 arms inclined 0·40 metre (1·3 foot) from the radius. This ventilator drives the air from one of the shafts. It is of steel, and makes 110 revolutions per minute, requiring 56 horse-power to drive it. This speed clears the tunnel from smoke in from 3¼ to 4½ minutes after a train passes, according to the direction of the train, for the ventilator is not in the middle, but at one end of the tunnel. C. Z. B.

DESCRIPTION OF A NEW BRIQUETTE MANUFACTORY AT THE CAROLINE COLLIERY, WESTPHALIA.

Beschreibung der neuen Briquette-Anlage auf der Zeche Caroline bei Holzwickede (Westphalen). By M. WAHLBERG. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen, Vol. XXXI., pp.* 61–62, *Plate III.*

In France the manufacture of briquettes is most extensive, and the system adopted is principally that of Bietrix & Co., St. Etienne. Lately Couffinhal, of St. Etienne, has introduced a new method which has been adopted by six collieries in Westphalia.

The coal to be used is put into a hopper, into which coal tar is fed. The mixture is brought by a Jacob's ladder to a disintegrator, where it is intimately mixed. A second Jacob's ladder raises it to a heating furnace, which consists of a slowly revolving round iron table, upon the centre of which the mixture falls, and is gradually carried towards the circumference, it is there caught by an endless screw and taken to the press mill. This mill subjects the mixture from two sides to a pressure of 180 atmospheres, and it is then forced out in the shape of a brick. The whole process is simple, and the double pressure in the mill unlike the other systems. According to the weight of the brick made 3, 5, and 10 kilogrammes respectively (6·6, 11·0, 22·0 lbs.), 50, 80, and 150 tons respectively of bricks can be made in 10 hours.

The cost is as follows:—

1.—One briquette machine with rotary furnace, ladders, and everything complete, with engine 19·7 in. cylinder, 31·5 in. stroke, with expansion regulator		£2,500
2.—Building, foundations, materials, etc.	£450	
Iron chimney and leather driving belt	150	
	——	600
3.—Boiler and steam pipes	450	
Ground	250	
Other charges	100	
Miscellaneous	100	
	——	900
		£4,000

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The cost of labour for one year of 300 days, with one daily 10 hours shift, making 24,000 tons a year, is—

1.—One foreman, 300 days at 3s.	£45 0
2.—One stoker and engineman, at 2s. 6d.	37 10
3.—One furnaceman, at 2s. 6d.	37 10
4.—Two men to serve the disintegrators, at 2s.	60 0
5.—Four boys to load the bricks, at 1s.	60 0
	£240 0

The amount of fuel used amounts to 2½ per cent. of the production of briquettes (about 2 tons per day) including boiler fuel, and for this purpose spoilt briquettes are used.

The cost of working for one year with a production of 24,000 tons is—

1.—5 per cent. interest on capital, £4,000	= £200
2.—10 per cent. amortisation on £4,000	= 400
3.—Wages	240
4.—Office and sale expenses	100
5.—Fuel for boiler and furnace, 2 tons at 5s. for 300 days ...	150
6.—Stores and repairs	75
7.—22,640 tons of small coal, at present price of 4s. per 300 days	4,528
8.—Coal tar, 5 per cent. of the coal used = 1,360 tons at 24s.	1,632
	£7,325

The production is equal to 22,640 tons of coal and 1,360 tons of coal tar, and, allowing 2 per cent. for loss, is equal to 23,520 tons of patent fuel, costing $\frac{7325}{23520}$ = 6·2s. per ton. Deducting the small coal used at 4s. per ton the cost of making patent fuel, exclusive of the coal comes to 2·2s. per ton.

Since this has been written the production has been increased beyond the figure here given. C. Z. B.

THE PRUSSIAN ROYAL FIRE-DAMP COMMISSION.

Commission zur Untersuchung und Prüfung von Sicherheitsmaassregeln gegen schlagende Wetter. Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXXI. A, pp. 19, 20.

Meeting on the 30th November, 1882 (Berlin Mining Academy); Dr. Serlo in the chair; twenty-three members present. Local reports from Breslau, Halle, and Clausthal were considered, and further experiments ordered at some more important mines. The analyses being made at Bochum of gas and air, were further considered. A proposal to send a Fire-damp Commission abroad was negatived.

Meeting on the 1st December, 1882 (Berlin Mining Academy). It was agreed that all the special reports should be published as they appeared in the "Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate," while the remaining work should remain as yet private. The report on explosions of fire-damp during the years 1861-81 was gone into, and it was decided that the statistics should be carried on now from year to year in the general form adopted.

Meeting on the 2nd December, 1882 (Berlin Mining Academy). A Safety-lamp and a Ventilator Sub-Commission were appointed, each consisting of four members.

C. Z. B.

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ROPE AND CHAIN HAULAGE AT THE ROYAL COAL MINE VON DER HEYDT, NEAR SAARBRÜCKEN.

Die Seil- und Kettenförderungsanlagen der Königlichen Steinkohlengrube Von der Heydt bei Saarbrücken. By HERRN VOLLERT. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXX. B, pp.* 299–318, *Plate XIV., and Text Plate.*

This colliery was the first on the Continent which introduced tail-rope haulage, viz., in 1862.

There are four haulage planes now. The first is a tail-rope haulage on the surface; second, underground tail-rope haulage; and third and fourth, endless chain roads on the surface, the details of which are given in the paper.

Dynamometer experiments were made on No. 4 haulage, at nine different equidistant points, both on the full and empty road. This plane is 1,760 metres (1,815 yards long, the chain, of best wrought iron, 20 millimetres (·787 inch) diameter, and weighs 8·58 kilogrammes per metre (17¼ lbs. per yard). It has been in use eight years, and will probably last other five. The tension at the heaviest point —that is, at the end where the full tubs came in—was 3,747·8 lbs., and it decreased along the full road to 2,425·1 lbs. at the turning point. At the commencement of the empty road it was 1,322·8 lbs., and increased to, when the empty tubs arrived at the end of their journey, 2,204·6 lbs. At the time of the experiment the velocity was 1 metre per second (3·28 feet per second), and the calculated horse-power 15. The indicated horse-power of the engine was 19·58 when seventy full tubs at 16·7 cwts., and sixty-seven empty ones at 6·9 cwts., were travelling with a velocity of 1·17 metre per second.

Table I. shows all the dimensions of everything connected with the four engine planes. Then follow tables of work done, cost of maintenance, labour, and capital for the years 1875–80. From one of the tables the cost per $\frac{100 \text{ cwts.}}{100 \text{ metres}}$, including cost of labour, maintenance, materials, exclusive of interest, of capital and depreciation, was during the years 1875–80 equal to 0·284d. for No. 1 plane, 0·312d. for No. 2, 0·415d. for No. 3, and 0·243d. for No. 4.

Taking into account the great wear and tear of the ropes, together with the greater speed by rope haulage, chain haulage is cheaper and to be preferred. The disadvantages of chain haulage are, however, that curves require to be struck with a short radius, and they (the curves) must be separated by straight roads, and the system requires a double way. C. Z. B.

SELF-ACTING ROPE FASTENER FOR WINDING.

Selbstwirkende Seilfangvorrichtung für Fördereinrichtungen. By W. LAUTE. *Berg- und Huettenmænnische Zeitung,* 1883, *p.* 69, *Plate II., Fig.* 21.

This arrangement is best adapted to the Koepe system of winding, when in the case of one rope breaking the other is prevented from falling down the shaft. The pulley round which the rope passes is fixed to a movable frame, which has its fulcrum in the centre, and is weighted at one end by means of a lever. The counterbalance weight is less than the weight of the empty cage, but greater than the weight of one side of the rope in the shaft. Over the pulley lies a brake block, which is held by rods fixed to a boss fitted eccentrically on the pulley shaft in an upright position. If the rope breaks on one side of the pulley, the counterbalance weight pushes the pulley against the brake block at the same time that wedges are automatically inserted under the movable frame in order to keep it up. As soon as the pulley touches the brake block it moves round from its upright position, and, owing to its eccentric boss, wedges itself tight against the pulley, and prevents the rope from slipping. C. Z. B.

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THE CAMPHAUSEN SHAFTS OF THE ROYAL DUDWEILER-JÄGERSFREUDE COLLIERY, NEAR SAARBRÜCKEN.

Die Camphausen-Schächte der Kgl. Steinkohlengrube Dudweiler-Jägersfreude bei Saarbrücken. *By* DR. KLOSE. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXXI. B, pp.* 1-12, *Plates I.-VI.*

The author, after describing the general position of the seams worked, the condition in which they are found, together with the surface arrangements of the colliery (Plate I.), and the sinking and walling of the shafts, of which there are three, gives particulars concerning the winding engine of No. 1 Shaft, which is the principal winding pit, as follows:—

Greatest depth	700 metres	=	765½ yards.
Effective weight, 6 × 500 kilogs. =	3,000 kilogs.	=	59·05 cwts.
Weight of cage	2,500 ,,	=	49·21 ,,
Do. 6 empty tubs	1,800 ,,	=	35·43 ,,
Do. 1 metre rope (round, cast steel)	10 ,,	=	22·05 lbs.
Steam pressure per square inch ...	5atm.	=	73·53 ,,
Speed per second	10 metres	=	32·8 feet.
Diameter of flat drum	8 ,,	=	26·25 ,,

The counterbalance arrangement consists of a special drum, to which is attached by means of a rope a counterbalance working in a pit. The greatest unbalanced weight is 7,000 kilogrammes (137·79 cwts.) acting on a radius of 4 metres (13·12 feet) on the drum circumference. The axle of the spiral drum is in the same line as the main axle, and is attached thereto by a trail crank. The greatest diameter of the spiral drum is 16·4 feet, and its smallest 4·92 feet, and contains as many grooves as there are revolutions per winding of the main drum. Attached to this spiral drum is a rope, the ends of which are fastened to the small diameter of the drum, and which passes over two pulleys into a pit, and forms a loop in the same, which supports a pulley 13·12 feet in diameter, to which is attached the counterbalance. At the beginning of a winding, one end of the counterbalance rope unwinds itself from the big diameter, and coils itself on the other end on the small diameter, and as the unwrapping of the rope is quicker than the wrapping, the counterbalance descends, and in the middle of the winding is stationary, and then for the remainder of the winding ascends. The distance which the counterbalance weight passes through in one winding is the depth of the pit, which is for a 700 metre (765·5 yards) shaft 76·95 metres (84·16 yards), and for the present winding depth of 496 metres (542·5 yards), 39 metres (42·7 yards). In a depth of 700 metres, and with a rope weighing 10 kilogrammes per metre, the weight is 16,000 kilogrammes (15·7 tons), and for the present depth of 496 metres, with a rope of 8 kilogrammes per metre, the weight is 12,800 kilogrammes (12·6 tons).

The pulley frame, Plate III., is constructed of wrought iron. The centre of the pulley axle is 20 metres (65·6 feet) above the ground, and the frame consists principally of six lattice girders, of which two stand vertically and the others are inclined. The centre line between the two ropes forms with the vertical an angle of 70 degrees, and accordingly the main stay girder has an angle of $\frac{1}{2}^{0}$ = 35 degrees with the vertical. The maximum breaking weight of the rope is taken at 140,000 kilogrammes (137·789 tons). To this add the varying weight of the descending rope 10,000 kilogrammes (9·84 tons), and the greatest strain in the direction of the main stay girder is—

	Kilogrammes.		Tons.
$R = 2 P \cos. 35^{\circ} = 2 \times 150{,}000 \times 0{\cdot}819$ =	245,700	...	241·82
To this add half the weight of the girder ...	8,000	...	7·87
	253,700		249·69

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or, in round numbers, 254.000 kilogrammes (249·99 tons), as the greatest strain on the chief girder. The four lattice girders forming the piece are strengthened by horizontal and diagonal rods, so that the strain on the angle iron can be gone into. The total cross section of the angle iron is 506,249 millimetres (78·47 square inches), so that per square millimetre the maximum strain is $\frac{254000}{50624}$ = 5 kilogrammes, or 7,000 lbs. per square inch.

The weight of the framing is—

	Kilogrammes.
Front portion	10,715
Main stay	15,859
Pulley platform	5,408
Four stiffening brattice girders	1,697
Foundation screws, anchor plates, etc.	6,321
Total	40,000 = 39·37 tons.

The pulleys are 5 millimetres (16·4 feet) in diameter, and weigh with axles and bearings 11,300 kilogrammes, so that the total weight of the pulley frame and pulleys amounts to 51,300 kilogrammes (50½ tons) and cost to erect £1,000. The calculation of the different strains is gone into and shown.

The description goes on with the guides, which are of wood, the keps, the self-acting shaft gates (Plate IV.), the boilers, of which there are nineteen Lancashire, 23 feet long, 6·56 feet in diameter, tubes 2·296 feet in diameter, the steam pipes, and the ventilator. The ventilator, Plate V., is a Guibal, 32·8 feet in diameter, and 9·84 feet wide, which receives its air from both sides. The blades are fastened in a new style, being materially strengthened by angle iron. The air compressors deliver 100 to 120 cubic metres (3,531·7 to 5,297·49 cubic feet) per hour at a pressure of from 4 to 5 atmospheres.

The screen arrangement, Plate VI., is known as the Briart system, and the coals are fed into the wagons, to avoid breakage, by a Jacob's ladder, which can be raised at will as the wagon fills. C. Z. B.

LÉON DRU'S PERCUSSION BORING MACHINE, WITH HYDRAULIC PRESSURE.

Freifallinstrument mit hydraulischem Druck nach Léon Dru. *By* BERGRATH TECKLENBURG. *Berg- und Huettenmænnische Zeitung*, 1883, *p.* 65, *Plate II.*, *Fig.* 1–9.

It is rather difficult to describe this borer without sketches, but the principle may generally be described as follows :—

The chisel is attached to a rod which forms a long loop, at the top of which is fastened a rod having at its lower end a piston attached. The top rods end in a fork, to which is attached a cylinder which lies in the loop of the lower rod and chisel. This cylinder is of a narrower bore at the top half than the lower half, and is closed at the bottom, while the piston is pierced with air holes. The borer only works in holes filled with water. Suppose the chisel to be at the bottom of the hole, then the piston will be at the bottom of the cylinder in the wide bore, the upper rods being then in their highest position. The upper rods now commence the down stroke, and the cylinder is moved downwards, while the piston, with chisel attached, remains stationary, and at the end of the stroke is at the top of the cylinder. Now the upper rods are lifted, and with it the chisel, for it can only fall slowly during the quick upstroke of the rods on account of the small bore, but the piston passes in time, owing to the weight of the chisel, into the wider cylinder, where it falls freely. The stroke of the upper rods is greater than the fall of the boring chisel. C. Z. B.

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A VISIT TO THE COAL-FIELDS OF ENGLAND IN THE AUTUMN OF 1881.

Bericht über eine im Spätsommer 1881 *ausgeführte Studienreise in die Steinkohlenbezirke Englands. By* HERRN FABIAN. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXX., B, pp.* 325-338.

The author describes and criticises the haulage at Boldon and Medomsley, in Durham; at Townley, in Lancashire; and at the Pope and Pearson Collieries, near Normanton.

He then describes the Swan electric light at Earnock Colliery, near Glasgow, as follows:—A single cylinder engine drives a Gramme machine. The latter makes 1,292 revolutions per minute, and supplies eighteen lamps, of which one is on the surface, and seventeen underground. A sketch in the letterpress shows their position. The furthest lamp from the shaft was 275 metres (300 yards); the total length of circuit was 1,450 metres (1,586 yards). The lamps burned with an average power of from fifteen to twenty candles, but each showed considerable difference. This was not owing to the resistance of the length of circuit, but to the internal resistance of the lamp. A trial was made with the lamps in a pair of working places at a distance of 685 metres (749 yards) from the shaft, making the total length of circuit 2,270 metres (2,482½ yards), with twenty-two lamps. The light was good, but on account of there being no gas it was discontinued, open lights being easier to work with. The power required was considerable. It was proved that four horse-power was required to work twenty-two lamps by 1,564 revolutions of the Gramme machine.

A criticism of the lighting follows, which is favourable as regards the lamp itself, but not as to the use of electricity in mines with circuits, on account of the danger of a spark attending the breaking of the circuit by accident. C. Z. B.

THE WORKING OF THE PRUSSIAN MINES IN 1881.

Der Bergwerksbetrieb im Preussischen Staate im Jahre 1881. *Zeitschrift für das Berg-, Hutten- und Salinen-Wesen im Preussischen Staate, Vol. XXX. Statistical Part* 2, *pp.* 109-223.

This part deals with the several Government districts and coal-fields, with coal and lignite mining, showing in each the production, number of collieries, number of workmen, officials, and their several wages and salaries; value of production; number of horses and engines, and their power; distinguishing number of pumping winding, and other engines, etc.; names of the mines, the exploring done in each mine, and the opening out of new tracts of lands, with exports of mineral by rail and canal. The same is shown for all other branches of mining and working of minerals.

In upper Silesia the average wages for the year 1881 were:—Enginemen, 2·06s. per day; hewers, 2·25s.; putters and drivers, 1·46s.; other underground men, 1·43s.; surfacemen, 1·38s.; boys, 0·70s.; and women, 0·73s. In the north part of the Westphalian coal-field the wages averaged for the hewers 3s. a day, while the other workmen received from 2s. to 2·50s. In the south portion the hewers' wages varied from 2s. to 2·50s. per day, and the other men employed underground from 1·50s to 2s. Of the Westphalian production, 78·96 per cent. was sent away by rail, 10·38 per cent. was coked, 6·21 per cent. was used for colliery consumption, 4·33 per cent. went by roads, and 0·12 per cent. by the river Ruhr. There were in this coal-field 2,185 engines of all sorts, with a combined power of 148.457 horse-power, of which there were 123 ventilators, 402 winding engines, 324 pumping engines, and 59 locomotives. The following table gives interesting particulars concerning the coal and lignite basins:—

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Coal.

Coal Basins.	No. of Mines in 1881.			No. of Workmen.	Production.				Value of Production at Pit.				Average Number of Workmen Employed per Mine.
	State Mines.	Private Mines.	Total.		Total.	Percentage of Total of State.	Yearly Average.		Total.	Average.			
							Per Mine.	Per Person Employed.		Per Mine.	Per Person Employed.	Per Ton.	
					Tons.		Tons.	Tons.	£ s.	£ s.	£ s.	s.	
Coal Basins—													
Upper Silesia	2	107	109	33,554	10,403,871	23·76	95,448	310	2,094,906 17	19,219 7	62 9	4·03	..
Lower Silesia	..	42	42	12,469	2,706,977	6·18	64,452	217	848,972 14	20,213 13	68 2	6·27	..
Wettin	1	..	1	123	9,869	0·02	9,869	80	5,778 6	5,778 6	47 0	11·71	..
Löbejün	1	1	2	120	19,788	0·05	9,894	165	7,879 11	3,939 16	65 3	7·96	..
Province Hanover (Wealden coal)	3	11	14	2,651	351,801	0·80	25,128	133	113,442 0	8,013 0	42 16	6·45	..
Duchy Hohnstein	..	3	3	30	1,781	..	594	59	608 12	202 17	20 6	6·83	..
Schaumburg (half)	1	..	1	773	108,865	0·25	108,865	141	48,277 15	48,277 15	62 9	8·87	..
Minden	..	4	4	174	10,193	0·02	2,548	59	4,520 3	1,130 1	26 0	8·87	..
Ibbenbüren	1	1	2	1,209	180,779	0·41	90,389	150	66,334 15	4,519 10	54 17	7·34	..
Ruhr	..	192	192	82,239	23,576,980	53·85	122,797	287	5,364,571 17	27,940 10	65 5	4·55	..
Aix-la-Chapelle	..	17	17	5,917	1,203,761	2·75	70,809	203	348,255 19	20,485 13	58 17	5·79	..
Saar	9	4	13	22,920	5,205,880	11·91	400,452	227	1,945,149 12	149,626 17	84 17	7·47	..
Total 1881	18	382	400	162,179	43,780,545	100·00	109,451	270	10,848,698 1	27,121 15	66 17	4·99	..
,, 1880	18	387	405	155,006	42,172,944	100·00	104,134	272	10,530,853 6	26,002 2	67 19	4·96	..
In-(de)-crease	..	(5)	(5)	7,173	1,607,601	..	5,317	(2)	317,844 15	1,119 13	(1 2)	0·03	..

Lignite.

Provinces—													
Brandenburg	..	102	102	3,497	1,777,564	17·07	17,427	508	213,636 5	2,094 9	61 2	2·40	34
Posen	..	6	6	110	28,632	0·27	4,772	260	5,211 3	868 11	47 7	3·64	18
Silesia	..	40	40	1,200	434,351	4·17	10,858	362	74,773 9	1,869 7	62 6	3·44	30
Saxony	4	227	231	13,503	7,798,582	74·90	33,760	578	1,202,563 15	5,205 18	89 1	3·08	58
Hanover	..	3	3	12	415	0·01	138	35	78 9	26 3	6 11	3·78	4
Hessen Nassau	4	39	43	1,105	179,021	1·72	4,163	162	42,989 0	999 15	38 18	4·80	26
Rhine Province	..	31	31	532	193,588	1·86	6,245	364	24,197 10	780 11	45 10	2·50	17
Total 1881	8	448	456	19,959	10,412,153	100·00	22,834	522	1,563,449 11	3,428 12	78 7	3·00	44
,, 1880	8	461	469	19,757	9,874,888	100·00	21,055	500	1,508,288 6	3,215 19	76 6	3·06	42
In-(de)-crease	..	(13)	(13)	202	537,265	..	..	22	55,161 5	212 13	2 1	(0·06)	2

C. Z. B.

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THE MINING INDUSTRY AND MINING ADMINISTRATION OF PRUSSIA DURING THE YEAR 1881.

Die Bergwerks-Industrie und Bergverwaltung Preussens im Jahre 1881. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXX. B., pp.* 383–414.

1.—General Position of the Trade.

A.—Mining Industry.

Although the production showed an increase, prices remained at a low ebb, especially during the first half of the year.

The production* of the mines (including rock salt) increased 4·57 per cent., and the value of the same 3·67 per cent. over the preceding year.

The total number of mines was 1844:—398 collieries, 456 lignite mines, 729 iron ore mines, 187 lead. zinc, and copper mines, 11 salt mines, and 63 other mines. The number of persons employed increased 4·65 per cent. on the preceding year.

a.—Coal Mining.—The mild winter of 1880-81 was unfavourable to this trade, but after a time the increased activity in the iron trade made itself felt without, however, enabling the coal-owners to increase their prices. In the beginning of the autumn prices began to get better, and, although the winter of 1881–82 was mild, the iron industry kept prices up. The production rose 3·81 per cent. and its value 3·02 per cent. in the preceding year, and the average price at the pit's mouth went back from 4·99s. per ton to 4·96s. The number of persons employed increased 4·63 per cent. in 1880. The exports rose 8·84 per cent. and the sales inland 5·03 per cent., together an increase of 5·64 per cent.

b.—Lignite Mining.—This trade has been good, especially that of the lignite briquettes. The production rose in 1881 5·44 per cent., its value 3·66 per cent., while the price per ton decreased from 3·05s. to 3·00s. The number of persons employed rose 1·02 per cent. in comparison with 1881.

c.—Iron Ore Mining.—In comparison with 1881 the production rose 6·17 per cent., its value 5·14 per cent., and persons employed 3·8 per cent. The price fell from 6·83s. per ton to 6·77s.

d.—Zinc and Lead Mining.—The production over the preceding year of zinc ores was increased by 4·33 per cent. and its value 19·58 per cent. The lead ores won amounted to 148,790 tons, an increase of 4·14 per cent. and in value 2·47 per cent. The price per ton fell from 127·15s. in 1880 to 125·11s. in 1881.

e.—Copper Mining.—The amount of copper ores raised was 515,360 tons, an increase of 8·89 per cent. over 1880, in value 20·12 per cent., and persons employed 13·28 per cent.

f.—The Mining of other Minerals.

g.—Mineral Salts.—The mining of salts, especially potash salts, was very prosperous. Rock salt rose as to production over 1880 25·92 per cent. and its value 28·78 per cent., while in potash salts the rise was respectively 36·40 per cent. and 39·67 per cent.

h.—The Mining or Quarrying of Stones and Earths.—Slate mining has not been prosperous, owing to competition from abroad, especially that of England. The same has been the case with the quarrying of basalt and calcareous tuff. The demand for phosphorite has been considerable, owing to the increased manufacture of super-phosphates and small phosphate imports from Chili and Peru. The working of strontianite in Westphalia by the Government has also been very successful.

For detailed production see Abstract, Vol. XXXII., page 18, of these Transactions, "Mining Production of Prussia during the Year 1881."

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B.—METALLURGICAL WORKS.

In 1881 there were 104 blast furnace works, 661 foundries, 273 puddling works, and 54 Bessemer steel works, in connection with the manufacture of iron and steel.

a.—Iron and Steel Works.—There were 186 blast furnaces at work, which produced 2.172,909 tons of iron. 1,159,104 tons of wrought iron and steel were produced, which included the manufacture of 5,549 tons of rails. The greatest activity prevailed in the steel works. The production of 1881 was 31·71 per cent. more than in 1880, being 864,502 tons. Of this 494,018 tons were manufactured into rails.

b.—Zinc Works. c.—Lead Works. d.—Copper Works. e.—Silver and Gold Works. f.—Other Works.

C.—THE MANUFACTURE OF SALT FROM SOLUTION.

2.—The Fiscal Mines and Works.

A.—GENERAL SUMMARY.

There were at work in 1881 18 fiscal collieries, 8 lignite mines, 16 iron mines, 4 lead, copper, lead and silver works, and 3 mineral salt works. There were 5 iron mines and 8 lead, silver, and other metallurgical works.

B.—PRODUCE OF THE FISCAL WORKS.

3.—Researches.

A.—GEOLOGICAL SURVEY.

The State geologic-agronomical works have been actively pursued in the Harz, Thüringen, Province Hessen-Nassau, Rhine Province, and Brandenburg Province. In the east and west provinces of Prussia work has lately been commenced. In all 91 geological sheets have been published. The following works in connection with the Geological Survey have been published:—1. "The Geology of the neighbourhood of Berlin," by Dr. E. Laufer and Dr. F. Wahnschaffe; 2. "The Geology of the Province Schleswig-Holstein," with a Map to the scale of $\frac{1}{500000}$, by Dr. L. Meyn; 3. Transactions of the Geological and Mining Academy of Berlin; 4. "The Flora of the Carboniferous System," by Dr. E. Weiss.

B.—BORE TRIALS.

a.—By the Government.—The Government undertook the boring of four holes during the year. One of the holes, commenced in 1880 near Domnitz, for the further inquiry into the coal formation of Wetten-Löbejün, was brought from a depth of 933 20 metres in very hard conglomerate and sandstone to a depth of 1001·20 metres. It has not been possible to determine the geognostic horizon of the strata passed through. Another hole, near Halle, at Schladebach, was put down to find the older coal formations, and at a depth of 591·32 metres was stopped in the lower new red sandstone.

b.—Other Works.—The boreholes seeking salt near Stassfurt have been very successful at a depth of 300 metres. 91 metres of rock salt was met with, together with 31 metres of potassium salts. Borings are actively pursued at Zscherben, near Halle, and Aschersleben, for the same purpose. The petroleum wells near Oelheim are extending. There are now twenty different companies with about eighty boreholes. The depth is from 60 to 199 metres. The petroleum is found at from 60 to 100 metres in depth under a bed of hard sandstone in a porous sandstone or loose sand. The area of great productiveness is at present limited to a stretch of land 400 metres long by 150 metres broad. The production amounted to 22½ tons per day in 1881.

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4.—Government Grants.

The number of leases asked for, for the working of mines, came to 139.

5.—Mining Taxes.

The States year of 1881-82 produced £185,659 from taxes, being 6·58 per cent. more than the year 1880, and nearly equal to the year 1876.

6.—Mining Colleges and Schools.

a.—Academies.—The Mining Academy of Berlin possessed during the year 92 students against 111 in the preceding year. The other remaining academy, in Clausthal, had altogether 85 students.

b.—Mining Schools.—There were 10 schools and 27 elementary schools in the whole State.

7.—Mining Laws and Mining Police.

During the year the Prussian State and the German Parliament have made no new laws with regard to mining. The Workmen's Accident Insurance Bill and the Sick Insurance Bill are rapidly being made law. The five Commissions sitting in the Government district of Dortmund to inquire into the damage done to houses, land, etc., by mining, have been hard at work settling claims.

8.—Transport.

a.—Railways, Roads, etc.—No new railways of importance have been opened, but the existing railway companies have been busy extending their railways. The Rhine-Meuse-Canal, owing to the action of the Dutch Government, has been stopped. The project of connecting the Westphalian coal-field with the ports of the North is about to be realized. The route has been fixed, and will be made in four parts—1st, the Emscher Canal from Ruhrort (Rhine) to Dortmund; 2nd. a canal from Henrichburg (Emscher) by Münster to the Lower Ems; 3rd, a canal from the Lower Ems to the lower part of the Weser; 4th, a canal from the Weser to the Elbe.

9.—The Condition of the Men Employed.

a.—In General.—Although wages have not risen, owing to the low price of mining products, yet they have kept at the same height as in the foregoing year. Towards the latter part of the year the Government iron mine men, the lignite, copper ore, and rock salt miners, obtained an advance in wages. The men, however, have found regular employment. The emigration of the coal miners from Westphalia to America, which began in the autumn of 1880, continued in 1881 to the extent of about 1,700 persons. As the winter set in with better trade, this entirely stopped, and even some of the men returned.

b.—Relief Societies.—These number 83, embracing 2,196 mines and works. The number of members was 289,377. During the year relief was given to 95,759 persons. The income of these societies amounted to £702,424, and the expenditure to £657,649. The amount of property held by them was £1,073,970. C. Z. B.

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THE MINING PRODUCTION OF AUSTRIA IN THE YEAR 1881.

Bergwerksbetrieb in Oesterreich im Jahre 1881. *Berg- und Hüttenmännische Zeitung*, 1883. *Part* 12, *p.* 125.

Mineral Production.

Products.	Metrical Cwts. = 0·98420 Cwts.	Compared with 1880. (+) (—)	Per Cent.	Value in Gulden.	Compared with 1880. (+) (—)	Per Cent.
Gold ore	7,812	+ 6,562	512·66	12,810	— 2,490	19·39
Silver ore	123,835	— 1,897	1·51	3,030,297	— 103,262	3·39
Mercury ore	482,140	+ 28,400	6·26	491,171	+ 7,199	1·49
Copper ore	44,452	— 4,814	9·77	247,118	+ 41,643	20·26
Iron ore	6,189,638	— 778,685	11·17	1,788,202	— 194,044	9·79
Lead ore	135,424	+ 27,006	24·91	1,030,056	— 113,956	9·96
Nickel and cobalt ore	400·23	+ 241·05	151·3	500	— 603	....
Zinc ore	273,398	+ 57,759	26·78	361,003	+ 74,166	25·99
Tin ore	10,514	+ 4,274	68·49	....	....	....
Bismuth ore	135·6	....	....	....	....	....
Antimony ore	1,870	— 150	7·42	20,435	— 19,938	49·38
Arsenic ore	....	....	....	....	....	....
Uranium ore	59	+ 7·6	14·78	45,975	+ 12,337	36·67
Tungsten ore	625	+ 29	4·86	6,924	+ 1,788	34·81
Chromium ore	2,962	+ 184	6·6	15,498	— 1,104	6·6
Iron pyrites	83,178	— 15,482	14·79	96,922	— 15,290	13·63
Alum shales	811,518	— 191,414	19·08	63,085	— 10,279	14·01
Manganese ore	91 097	+ 2,353	2·42	95,219	+ 17,382	22·33
Graphite	133,792	— 3,385	2·46	536,693	— 8,169	4·99
Asphaltum	486	— 1,525	75·83	861	— 1,965	69·53
Lignite	89,614,983	+5,408,514	6·42	16,019,507	+ 643,750	4·18
Coal	63,433,159	+4,536,848	7·70	20,736,431	+ 1,399,703	7·24

Smelting Works Production.

Gold	0·186	— 0·228	54·83	26,046	— 32,254	55·32
Silver	313,596	+ 11 02	3·64	2,794,111	+ 98,003	3·63
Mercury	3,980·6	+ 289·6	7 85	771,908	— 3,771	0·49
Copper	4,819	— 182	3·64	355,082	— 27,075	7·08
Refined pig iron	3,378,436	+ 515,234	17·99	14,957,869	+ 1,866,571	14·25
Foundry pig iron	417,962	+ 78,144	22·99	2,613,580	+ 451,777	20·89
Lead	62,857	+ 7,417	13·14	1,159,840	+ 72,972	6·71
Litharge	29,961	— 5,945	16·55	514,813	— 137,188	21·04
Nickel and cobalt	....	....	....	....	....	....
Zinc	41,192	+ 3.635	9·68	708,555	— 4,157	0·58
Tin	394	+ 103	35·4	43,852	+ 9,469	27·56
Bismuth	5·84	+ 0·5	9·36	....	....	....
Antimony	839·60	— 409·78	32·79	2·,106	— 15,581	59 68
Arsenic	....	....	....	....	....	....
Uranium preparations	32	+ 3·61	12·71	63,327	+ 5,220	9·0
Sulphur	4,356	+ 335	8·33	30,282	+ 213	0·71
Sulphuret of carbon	1,779	+ 581	96·10	46,254	+ 22,906	96·10
Ferrous sulphate	11,950	— 72	0·6	42,180	— 2,349	5·27
Sulphates of the earthy metals	63,308	— 3,360	5·0	144,984	— 6,572	4·3
Sulphuric acid	142,677	+ 20,332	16·61	1,211,329	+ 39,549	3·37
Alum	20,404	— 634	3·01	145,847	— 21,089	12·63
Mineral colours, exclusive of uranium	14,674	+ 832	6·0	33,290	+ 3,424	11 4

The average price of lignite per metric centner (0·98420 cwts.) was 17·85 kilogrammes (less than 0·39 kreutzer in 1880, or 2·13 per cent.), that of coal was 32·69 kilogrammes (less than 0·14 kreutzer, or 0·004 per cent. in 1880).

The salt works produced 581 355 metric centner rock salt, 1,563,863 metric centner brine salt, 407,617 metric centner marine salt, and 119,959 metric centner industrial salt ("industrialsalz"), amounting in all to a value of 23,000,498 florins, an excess of 986,781 florins over 1880. C. Z. B.

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WAGNER'S POCKET LEVELLING INSTRUMENT.

Taschen-Nivellirinstrument von R. Wagner. *By* HR. MARTENS. *Wochenschrift des Vereines Deutscher Ingenieure*, 1883, *pp.* 119–120. *Text Plates, Figs.* 1, 2, 3, 4, *and* 5.

The principle of this instrument consists in reading the ordinary staff by means of a telescope at the same time that the instrument is levelled by a spirit level visible in the telescope. It is made in four sizes, and costs from 48 to 60 shillings. The largest size measures 6 inches × 2¾ inches × 1¼ inches, and weighs 10½ ounces. A light stand supports the instrument, but with practice it can be used by the hand alone.

C. Z. B.

THE MINING PRODUCTION OF THE GRAND DUCHY OF HESSE IN 1881 AND 1882.

Montanstatistik des Grossherzogthums Hessen. *By* HR. TECKLENBERG, *Berg- und Huettenmaennische Zeitung*, 1883, *Part* 15, *p.* 159.

	Works.		Production.			
			1881.		1882.	
	1881.	1882.	Metrical Tons.	Value in Marks = to Shillings.	Metrical Tons.	Value in Marks = to Shillings.
I.—Mining production—						
(*a*) Lignite	9	9	30,738	238,153	28,240	201,438
(*b*) Iron ore	18	14	133,261	850,753	111,105	666,981
(*c*) Manganese ore ...	1	1	1,071	26,282	87	3,310
II.—Salt from solution —						
(*a*) Common salt... ...	3	3	15,562	388,094	15,762	387,841
(*b*) Alum	1	1	462	64,680	129	19,298
III.—Smelting works—						
(*a*) Charcoal pig iron ...	1	1	1,477	115,170	229	17,209
(*b*) Coke pig iron... ...	2	2	33,420	2,506,515	34,491	2,586,750
(*c*) English sulphuric acid	1	1	7,000	280,000	8,726	261,674
IV.—Iron works—						
(*a*) Cast iron, 2nd fusion	13	12	4,946	915,129	4.899	981,808
(*b*) Wrought iron ...	1	1	86	13,760	80	12,825
Total	50	45	...	5,398,536	...	5,139,134

C. Z. B.

KLOHT'S NEW PLANIMETER.

Ueber ein neues Planimeter. *By* F. KLOHT. *Zeitschrift für Vermessungswesen. Vol. XII., pp.* 97–115. *Plate I.*

This instrument purposes to combine the good properties of the polar planimeter and the linear planimeter, the former being more accurate and independent of the nature of the plan paper, but complicated; and the latter being less complicated, less accurate, and dependent upon the nature of drawing paper. The instrument is constructed so that by means of polar movement the principle of the linear planimeter can be carried out, at the same time arriving at a greater degree of accuracy.

C. Z. B.

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PRUSSIAN FIRE-DAMP EXPLOSIONS FROM 1861 TO 1881.

Die auf den Steinkohlenbergwerken Preussens in den Jahren 1861 *bis* 1881 *durch schlagende Wetter veranlassten Unglücksfälle. Prepared for the Royal Fire-damp Explosions Commission by* A. HASSLACHER. *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate, Vol. XXX. B., pp.* 339–382.

This paper contains a large number of tables. The following is perhaps of most general interest:—

TABLE VI.

STATES.	PRODUCTION.	PERSONS EMPLOYED.	FATAL ACCIDENTS.		FATAL ACCIDENTS PER MILLION TONS RAISED.		FATAL ACCIDENTS PER 1,000 EMPLOYED.		Percentage of Fatal Accidents by Explosions to Total Fatal Accidents.
			Total.	By Explosions of Fire-damp.	Total.	By Explosions of Fire-damp.	Total.	By Explosions of Fire-damp.	
	Tons.								
Prussia ..1871–80	337,652,224	1,511,892	4,379	424	12·97	1·26	2·896	0·280	9·68
Gt. Britain 1871–80	1,329,961,005	4,821,832	11,349	2,686	8·53	2·02	2·354	0·557	23·67
Belgium ..1871–79	133,465,453	929,034	2,243	426	16·80	3·19	2·414	0·459	18·99
France ..1871–80	167,744,966	1,036,801	2,256	513	13·69	3·06	2·214	0·495	22·34
Austria ..1875–80	30,716,277	216,797	457	61	14·88	1·99	2·108	0·281	13·35
Saxony ..1871–80	31,064,368	*125,383	532	161	17·09	5·19	4·243	1·284	30·26
....	....	(156,729)	....	....	....	....	(3·394)	(1 027)	....

* Underground men only. The figures in brackets deal with the total number employed.

C. Z. B.

THE MINING INDUSTRY OF AUSTRIA IN 1881.

Der Bergwerksbetrieb in Oesterreich im Jahre 1881. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen, Vol. XXXI., Part* 11, *pp.* 150–153, *and Part* 13, *pp.* 180–182.

In the whole of Austria there existed at the end of the year 1881, 29,674 free grants for the seeking and winning of minerals, an increase of 5·89 per cent. over the foregoing year. The results of some of the explorations were, that in Schöndorf, near Podersam, a 60 metres deep bore-hole traversed basalt overlying the tertiary formation without finding lignite. In Silesia, coal was traced in Peterswald and Orlau-Lazy. Lignite was discovered at Fohnsdorf, in Steiermark; graphite at Mautern, in Rauach; and iron ore in Gollrad. Near Trieste a company is actively engaged in exploring the eocene lignite formation. Improvements in mining appliances are recorded.

During the year 1881, there were 791 mines and 119 smelting works at work, employing 85,492 and 10,170 persons respectively, a total of 95,662 persons; of whom 87,002 were men, 6,006 women, and 2,654 children. In coal mining 37,113 persons were employed, an increase of 1·59 per cent. on the preceding year. In lignite mining 29,083 persons were employed, or 0·22 per cent. increase on 1880.

There were 167 deaths by accidents, and 204 persons severely injured. Of the former, 68 took place in coal mining and 78 in lignite mining, or 2·0 and 2·9 per 1,000 employed, respectively. Of the latter, 73 took place in coal mining and 89 in lignite mining, or 2·1 and 3·3 per 1.000 employed. respectively.

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The tons raised per death by accident in coal mining were, in 1880, 57,741, and in 1881, 46,642; in lignite mining, 69.021 in 1880, and 57,445 in 1881. The tons raised per severely injured were. in coal mining, in 1881, 22,494, and in 1880, 23,006; in lignite mining, 26.831 in 1881, and 29,443 in 1880.

The causes of all accidents, amounting to 167 deaths and 204 severely injured, of which coal and lignite mining together share to the extent of 81 per cent., are detailed as follows:—

	No. of Accidents.						Percentage to Total.	
	Fatal.		Severely Injured.		Total.			
	1881.	1880.	1881.	1880.	1881.	1880.	1881.	1880.
By falls in the mine	61	46	53	66	114	112	30·7	32·3
„ falling in shafts	14	14	4	3	18	17	5·1	4·9
„ vehicles	21	15	38	31	59	46	15·9	13·2
„ fire-damp	6	10	19	15	25	25	6·7	7·2
„ noxious gases	11	2	1	...	12	2	3·2	0·6
„ machines	6	7	14	7	20	14	5·4	4·0
„ kirving	13	6	11	6	24	12	6·5	3·5
„ falls of surface ground ...	5	7	6	5	11	12	2·9	3·5
„ travelling in shafts	6	8	1	5	7	13	1·9	3·7
„ blasting with gunpowder ...	5	4	6	16	11	20	2·9	5·8
„ „ nitro-glycerine preparations	1	...	18	13	19	13	5·1	3·7
„ other than blasting explosions	1	1	...	4	1	5	0·3	1·4
„ water	...	1	...	...	...	1	...	0·3
Other causes	17	21	33	34	50	55	13·4	15·9
Total	167	142	204	205	371	347	100	100

The mining revenue raised during the year 1881, amounted to 1,313,830 florins 565 kr. In the whole of Austria the tax on mining was 2·16 per cent. of the value of the minerals raised, exclusive of the salt industry. C. Z. B.

A CHRONOLOGICAL REVIEW OF A NUMBER OF SHAFT BORINGS.

Chronologisch geordnete Uebersicht einer Anzahl Schachtbohrungen. *By* Hr. Teckleburg. *Berg- und Hüttenmännische Zeitung*, 1883, *Part* 10, *pp.* 97–99.

The methods adopted depend upon the existence of a hard, water-containing rock or quicksand. In the former the systems of Kind-Chaudron, Lippmann, with tubbing or diamond boring, in the latter brick walling or iron tubbing are made use of.

In the mining district of Schönecke, at Stiring, near Forbach, Kind bored a shaft, commencing on the 18th December, 1848, 111 metres in sandstone and conglomerate, and 20 metres in coal measures. Wooden tubbing was used, which, however, did not prove successful. Compare Ponson, Traité de l'exploitation des mines de houille. T. 1, pp. 354–450, also Beer. Erdbohrkunde, p. 344, and Serlo, p. 647.

At the Anna mine, near Alsdorf, in the Worm district, two shafts were sunk during the years 1850-54, and lined with cast iron tubbing. They were put through quicksand, 49·29 metres in depth, by means of a "sackbohrer." The cost of sinking in the quicksand was 857 marks per metre (£39 3s. per yard). Compare Zeitschr. f. d. Berg-Hütten-u-Salinenwesen im Pr. Staate, 1855, p. 236.

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Three shafts were sunk through quicksand at the Maria colliery, near Hoengen, in the Worm district. in the years 1850–55. The quicksand was 28·88 metres in depth, and the cylinder lowered through the same was barrel-like, of pitch pine. The shafts were 133·88 metres deep, and were 1·31, 1·64, and 2·35 metres in diameter. The sack-borhrer was used. The cost in quicksand was 477 marks per metre (£21 16s. per yard).

At the colliery Dahlbusch, near Rotthausen, in Westphalia, five shafts were bored during the years 1852–75, by the Kind-Chaudron method. The shafts were—

No. I.	= 117·3	metres deep	and 3·5	metres	in diameter.
Air shaft	= 101·1	,,	1·9	,,	,,
No. II.	= 104·6	,,	3·65	,,	,,
,, III.	= 88	,,	3·65	,,	,,
,, IV.	= 88	,,	3·65	,,	,,

The cost, including tubbing of the air shaft, was £6,326 17s., shaft No. II. £14,680, Nos. III. and IV. together £28,350, or £141 15s. per metre, or £87 per metre for sinking only. Compare paper written by Director Schulz, in 1879, Serlo, p. 647, and Zeitschr, f. d. B.,- H.- W. S. im Pr. St., 1858.

The colliery Agnes Ludowike, near Hornhausen, was sunk from a depth of 15·69 metres in quicksand by means of a sinking wall and double sackbohrer. The cost was £18 15s. per metre in the quicksand. Compare Zeitschr. f. d. B.,- H.- u. S. im Pr. St., 1855, p. 228.

Near Ressaix, in Belgium, five shafts were sunk from 1854 to 1873 by the Kind-Chaudron system. In the shaft St. Vaast, at the Peronne colliery, the height of tubbing was 98 metres. The diameter was 3·65 metres, and the total cost £8,800, or about £89 16s. per metre. The shaft Ressaix was 3·65 metres in diameter. Cost, with tubbing, £6,000, or £69 9s. per metre. Compare Schulz, pp. 5, 29, 38.

In the Rheinpreussen colliery, near Homberg, Ruhrort, two shafts were sunk 326 metres, and 2·86 and 4·7 metres in diameter during the years 1857–1877. During these 20 years all conceivable plans of sinking through quicksand of over 100 metres in depth were repeatedly tried. Many accidents took place, and the undertaking cost many million marks. Compare Zeitschr. f. d. B.,- H.- u. S. im Pr. St., 1863, p. 43; 1869, pp. 88, 385; 1872, p. 95; 1875, p. 236; and 1879, p. 1.

Chaudron sank four shafts at the colliery L'Hôpitale, near St. Avold in Lothringen, in the years 1863–66 and 1874–76. Hard vogesen sandstone was sunk through with feeders amounting to 25 cubic metres per minute (5,502·42 gallons). Shaft I., 1·83 metres in diameter and 158 metres deep, cost, including tubbing, £11,250, or £71 4s. per metre; shaft II., 3·43 metres diameter and 159 metres deep, £17,600, or £110 16s. per metre. Compare Schulz, pp. 29, 38, 39.

Near Dorignies (Département du Nord) the Compagnie des mines de l'Escarpelle sunk a shaft from a depth of 25·98 metres to a depth of 104 metres, with a diameter of 3·2 metres, by the Kind-Chaudron method, in 1868–69. The sinking, including tubbing, cost £8,315, or £80 per metre. Later in 1869, 1870, and 1876–77, two more shafts were sunk 104 and 109 metres respectively, on the same plan. Compare Schulz, pp. 29, 38, 39.

A shaft at the Deutscher Kaiser colliery, at Mühlheim on the Ruhr, was sunk in the years 1871–75, by boring. Oxen were used for turning the borer. Compare Zeitschr. f. d. B.,- H.- u. S. im Pr. St., 1879, p. 67.

At Meurchin, in the north of France, two shafts were sunk on the Kind-Chaudron method, between April 1st, 1872, and July 31st, 1875. The shafts were 3·20 metres in diameter, and 84 and 91 metres deep, respectively. The total cost was £10,504 and £10,200 and the cost per metre, including tubbing, was £125 10s. and £113 6s. Compare Schulz, pp. 28–29.

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Zobel and Kohl bored two shafts, from the 24th March, 1873, to the 30th April, 1874, on their own plan, 1·41 metres and 44·43 metres deep, at Nortycken, in Samland, for the winning of amber. Several new and interesting tools were used in this work. Compare Zeitschr. f. d. B.,- H.- u. S. im Pr. St., 1874, p. 139, and 1879, p. 284.

On Lippmann's system, a shaft was bored at the Rhein-Elbe colliery, near Gelsenkirchen, in thirteen months, 1874–75, which was 90 metres deep and 4·3 metres in diameter. The freefall apparatus of Dégousscé and Laurent was adopted. Compare Zeitschr. f. d. B.,- H.- u. S. im. Pr. St., 1876, p. 176.

Lippmann's system was again used at the colliery Königsborn, near Unna, in an improved form known as Mauget-Lippmann. The shaft was 200 metres deep. The first 50 metres, and 4·5 metres diameter, was sunk by hand, the remaining depth was bored 4·3 metres in diameter. The boring commenced on the 20th August, 1875, and lasted until October, 1878. The machine worked very smoothly, and a progress was recorded of as much as 0·5 metres in 24 hours, and 11 metres per month. The tubbing was on the Kind-Chaudron principle, except that, instead of the central pipe, a valve was fitted to the false bottom which was actuated from bank by a steel wire. The rings were 1·5 metres high, and 123 were used. The cretaceous marl through which they sunk was partly of a flinty hardness. The cost of the apparatus is about four times dearer than that of the Kind-Chaudron. The system is admirably adapted for large shafts. Compare Zeitschr. f. d. B.,- H.- u. S. im Pr. St., 1876, p. 176, and 1877, p. 242.

The author concludes by saying that when sinking with tubbing, or walling, which is lowered as the work progresses in quicksand, is adopted, it is not advisable to force with much power the walling or tubbing when it will not sink, as it leads to frequent breakages and trouble. Experience seems to prove that after bringing by hand the shaft down as far as possible, the inner and outer diameters of the walling or tubbing should be so chosen that several smaller sized wallings can find room. The object should be more the freeing of the strata at the circumference below the walling, rather than the sinking of the shaft sump until the shaft has reached hard strata with but little water.

C. Z. B.

THE OIL INDUSTRY OF OELHEIM, NEAR PEINE.

Oelheim bei Peine. *By* R. BALDAUF, *Oesterreichische, Zeitscrift für Berg- und Hüttenwesen*, 1883, *Part* 9, *pp.* 113–114, *and Part* 10, *pp.* 133–134; *Figs.* 1–3, *Plate V.*

Oelheim lies near the villages Oedesse and Edemissen, on the Lüneburger Haide, 3 kilometres north of Peine (station on the Brunswick-Hanover railway). The petroleum district of Oelheim forms only a link of the great North German oil regions, which extends in a straight line from Schöppenstedt, in Braunschweig, in a north-west direction to Verden on the Aller, a distance of about 20 miles (German). At many points in this line, which runs parallel to the contour of the district, the existence of oil is proved, partly by traces of oil on the surface, partly by shafts, and boreholes and tar wells. The formation in which the oil is found seems to be the Wealden, and certainly the cretaceous sandstone bed belonging to the Wealden, which crops out, seems to contain the chief supply. This is, however, not the only deposit, as other clay and sandy strata, as proved by boreholes, yield, in pumping, oil much mixed with salt water.

The first successful commercial attempt to obtain oil was in 1880, and was followed by Herr Mohr, who bored the celebrated No. 3 borehole in December, 1880, well known on account of the strong eruption of gas from it. Now 25 different companies exist.

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The two original companies are the only producers at present, and their taking is studded with boreholes from 10 to 20 metres apart only. These holes gave very varying results; one hole producing 10 to 20 barrels a day, being next to one producing nothing; and this may be accounted for by a borehole weakening the productiveness of another close to it. Some of the holes (for instance Mohr's No. 13, which formerly gave as much as 100 barrels of raw oil per diem) show a decided decrease on their original supply. The production in 1881 was 22,000 barrels, and in 1882 104,113 cwts. The cost of putting down a hole is small, and is amply repaid if a yield per hole of from 3 to 4 barrels a day is secured The comparatively shallow depth at which the boreholes are at present confined gives rise to greater hopes on the attainment of greater depths.

Methods of Boring,—Percussion rod boring is the most common, with Fabian's freefall piece. These holes are started with a diameter of 420 millimetres. and diminish at depths of 100 to 200 metres to 160 to 100 millimetres in diameter. As soon as the dolomitic limestone has been passed through and soft shales are met with, the boring is changed to a rotatory motion. The percussion boring is invariably performed by hand, making progress in fairly hard rock to the extent of from 700–1000 millimetres per day. The bore-master, who undertakes the work at his own risk, charges 65 marks (£3 5s.) per metre for the first 100 metres, and 10 marks (10s.) per metre additional below that depth.

The American rope boring method, largely adopted in Pennsylvania, U.S., has not proved successful.

Percussion boring with wooden rods is used by the United Continental Oil Company, Limited, London, who are boring for a Bremer firm. The agreement is, that 200 metres must be reached, for which in return they receive half the yield of raw oil. The boring is 310 millimetres in diameter. The boring arrangement is the best in the district; a depth of 150 feet having been reached in one week.

An Essen firm are boring with hollow iron rods and water. The rods are formed of gas piping 34 millimetres in diameter, and the water is forced by a hand pump. The chisel is attached to the hollow piping. The boring is the deepest in the district, having attained a depth of 360 metres.

Köhrig's boring arrangement is similar to the foregoing, with the exception that attached to the hollow rods is a Fabian's freefall borer, and the water is forced outside the rods and comes up inside. The greater velocity obtained by making the water pass upwards in a narrower passage, enables the water to carry with it large *débris* and even whole cores.

The holes generally are lined with welded wrought iron pipes for great depths, and drawn iron pipes for lesser depths, with screwed joints, which are so well made that the joint is scarcely discernible. As later a lifting pump is made to work in them this is a great advantage. C. Z. B.

ACCURACY OF THE EQUIDISTANT PLANIMETER.

Versuche über die Genauigkeit des æquidistanz-planimeters. *By* F. GÜNTHER. *Zeitschrift für Vermessungswesen. Vol. XII., pp.* 37–43.

The author refers to his paper on the equidistant planimeter of his design in Vol. XI., made for computing small areas. In this paper he details trials made with it, together with the polar planimeter and the Harfen planimeter. The trials consisted of measuring the areas of circles and squares, representing areas respectively of 100, 500, 1,000, 2,000, 3,000, and 4,000 sgm. drawn to a scale of 1 : 4,000. Tables of the results are given. For small areas up to 4,000 sgm., on the scale of 1 : 4,000, the equidistant planimeter is as accurate as the others, and requires less time to manipulate. C. Z. B.

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THE SAFETY-LAMPS IN USE AT THE ROYAL COLLIERIES NEAR SAARBRÜCKEN.

Die auf den fiskalischen Steinkohlengruben bei Saarbrücken in Gebrauch befindlichen Sicherheitslampen. ROYAL PRUSSIAN FIRE-DAMP COMMISSION. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate, Vol. XXXI. B, pp.* 70–71.

1.—The Davy. The wire forming the gauze is ½ millimetre thick. The meshes are rectangular, and 144 go to a square centimetre. These lamps are only used by the officials for the purpose of examining the air, and then only in some districts.

2.—The Saarbrücken lamp, which is a Müeseler without the inner chimney and the horizontal gauze. The oil holder is much lower than in the Müeseler, being 37 millimetres high against 50 millimetres. The gauze is protected at the top by a copper cap which fits tight over the gauze, and is perforated to the same extent as the gauze. The lower part of the lamp. with the lower, middle, and upper rings with plate, are of brass, and the upper part of iron. The glass cylinder has a diameter (outside) of 65 millimetres, is 6 millimetres thick and 65 millimetres high, is made of well-tempered white glass of as even a thickness as possible, and accurately ground where it bears upon the plates. The wire forming the gauze is three millimetres thick, and 144 meshes go to a square centimetre. A round wick is used and the oil is of pure rape-seed. The lamps are locked by a screw fitted at the bottom of the oil-holder. The total weight is 850 grammes, against 990 grammes of the Müeseler. and 1,020 grammes of the lamps mostly used in Westphalia.

3.—Lately some of Dr. Schondorff's improved magnetic Bidder lock lamps have been successfully used at the Heinitz Colliery. C. Z. B.

BREAKAGE OF A WINDING ROPE AT THE DUKE HARDENBERG COLLIERY, WESTPHALIA.

Zum Seilbruch auf Zeche Fürst Hardenberg. By FRANZ PETERS. *Zeitschrift des Vereines Deutscher Ingenieure. Part* 3, *Vol. XXVII., pp.* 222 228.

The author endeavours to explain the reason of the rope breaking, an accident which caused the death of 25 men.

The rope consisted of seven strands, each constructed on a core of three wires made of annealed crucible steel, each wire being 0·005 inches in diameter. The seven wires next the core in each strand were of crucible steel, 2·2 millimetres (0·0866 inches) in diameter, and the twelve outer wires, made of the same material, were 2·4 millimetres (0·09449 inches) in diameter. The main core, round which the seven strands were twisted, consisted of six strands, each composed of six wires made of annealed iron 2 millimetres (0·0787 inches) in diameter, twisted on a tarred hemp core.

According to the regulations of the mining police 114·6 kilogrammes per square millimetre (72·8 tons per square inch) is the limit of strength for crucible steel; 80 kilogrammes per square millimetre (50·8 tons per square inch) for annealed crucible steel; and 45 kilogrammes per square millimetre (28·5 tons per square inch) for annealed iron wire; so that the strength of the rope was equal to a total carrying power of 71·42 tons.

By trials made at the manufactory, the rope proved capable of carrying 80·39 tons. The rope was again tested after the accident, when it was ascertained that after 11½ months wear the strength had deteriorated 18·25 per cent.

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The weight carried by the rope was 8·383 tons. This makes the rope to be 8·5 times stronger than the load, but really, according to the trials made, 9·6 times stronger, and after breakage 7·8 times stronger.

According to the regulations enforced by the mining authorities, the weight of men allowed to ride must not be more than half the weight when winding coal (in this case equal to 20 men). 25 men were in the cage at the time the rope broke; but this could hardly have been the cause of the accident.

On examining the rope after fracture it was found that five out of the seven strands were broken off nearly in one plane, and each wire was fractured as if it had been broken in a proof machine. The other two strands reached 150 millimetres and 250 millimetres beyond the fracture. This seemed to prove that the rope had broken suddenly. No marks were found on the guides to show that the cage had got wedged.

The rope broke 1·5 millimetre below the shackle, and had been four times re-socketed.

The safety apparatus did not act, owing, very possibly, to the suddenness of the break, as the axis holding the cams to catch the guides was found to be so bent as to unfit it for action.

The author's theory is that the cage was too rapidly nearing the top, and that the engineman slackened or stopped his engine so suddenly that the cage, after travelling with a velocity due to its momentum, fell back on the slack rope and so broke it. The banksman just saw the bridle chains when the cage went to the bottom. C. Z. B.

COAL STAITHS.

Mémoire sur les Moyens mécaniques employés pour décharger les wagons de Houille dans les bateaux et dans les Charettes. Par M. E. J. FOUGERAT. *Bulletin de la Société Industrielle du Nord de la France, No.* 38, 1883, *pp.* 107–121, *six folding Plates.*

The author describes and discusses the various systems adopted in England, Germany, and France.* He is in favour of the last; in all of which the wagons are placed parallel with the ship and emptied from one side.

On the whole he prefers the system devised by himself for the Bruay Coal Company (Pas-de-Calais), and for which he was awarded a silver medal at the Exhibition of 1878. The wagon (ten tons) is run on to a platform parallel to the ship. The platform is hinged along the side next the ship, and the other side is raised through an angle of about 30° by means of an hydraulic piston placed beneath it. One side of the wagon being opened, the coal is discharged into a spout.

Two of these tips complete, costing £1,600 (40,000 francs), will discharge 2,500 to 3,000 tons of coal in one day, and employ only six men. J. H. M.

A SUSPENDED CENTRING.

Una Cimbra Colgada. By M. GARRAN. *Revista de Obras Públicas. Sér.* 4, *Tomo I., Num.* 2, 1883, *pp.* 24–28. *One folding Plate.*

In order to connect two quays at Barcelona, it was necessary to arch over an opening twenty-four feet wide and fifty yards long.

The level of the sea being above the spring of the arch, centres fixed in the ordinary way would have been exposed to the force of the waves; it occurred, therefore, to the author to suspend the centres from balks resting upon the quay walls and an intermediate pier. This paper gives, with the aid of a plate, a detailed description of the suspended centring upon which the arches were successfully built. J. H. M.

* Some of the French systems are described in Vol. XXVII. of the Transactions.—SUB-EDITOR.

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IMPORTATION OF ENGLISH COAL AND COKE TO BILBAO.

Importacion de Carbones Ingleses en Bilbao. Revista Minera y Metalúrgica, 1883, *Série c, Tomo I., Num.* 8, *p.* 109.

Year.	Coal (tons).	Coke (tons).	Total (tons).
1878 ...	45,777 ...	12,477 ...	58,254
1879 ...	59,119 ...	13,077 ...	72,196
1880 ...	40,209 ...	42,366 ...	82,575
1881 ...	55,693 ...	46,850 ...	102,543
1882 ...	86,395 ...	66,219 ...	152,614

J. H. M.

THE ANZIN COAL STAITHS.

Note sur un Basculeur à contre-poids différentiels pour le déchargement des wagons de 10 *tonnes. Par* J. Déprez. *Bulletin de la Société Industrielle du Nord de la France, No.* 38, 1883, *pp.* 97–99, *two folding Plates.*

This is an account of the method adopted at the Anzin mines for loading vessels with coal. The truck (10 tons of coal) is run on to a platform parallel with the ship. This platform is hung upon a longitudinal axle, placed about four inches eccentric to the centre line of the rails, so that, on the withdrawal of a bolt, the weight of the full truck will tip one side of the platform down towards the vessel. The side of the truck being opened, the coal is discharged along a spout into the hold. The platform in turning picks up a series of weights, so proportioned as to exactly counterbalance the load, which increases as the angle of tip increases. In order to bring the platform and empty truck quietly back, some of the balance weights are prevented from acting immediately, by means of a brake. All the details are clearly shown in the plates. It is found in practice that four men can discharge from 250 to 270 tons in two hours.

M. J. Déprez has been awarded a gold medal for his apparatus. J. H. M.

DYNAMITE, ETC.

Communication sur les Diverses Variétés de Dynamite et la Gomme Explosive. Par M. Ed. Achard. *Bulletin de la Société Scientifique Industrielle de Marseille*, 1881, *pp.* 269–277.

The author describes nitro-glycerine and the different kinds of dynamite, including gum dynamite.

With reference to dynamite, he points out that the great safety of this explosive has, by inducing over-confidence, been the cause of many accidents; as, for instance, if a light be applied to a small quantity of dynamite, it will burn quietly, whereas, in the case of a large quantity, it will explode, and it is impossible to fix the limit. A thick layer of dynamite, such as an ordinary cartridge, may be struck with a hard body or subjected to the most violent shocks; but a thin layer, in similar circumstances, would explode. Accidents have often been caused by thawing dynamite that has frozen (which it does at a temperature of about 42° Fahr.) by placing it near the fire or upon a stove. This is in itself harmless, but if, as sometimes happens, a detonator has been left in one of the cartridges, a violent explosion might be the consequence. M. Achard recommends that dynamite should be thawed in an empty vessel placed in a vessel hot water. J. H. M.

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RESISTANCE TO TRACTION ON ROADS.

By RUDOLPH HERING, *President of the Club. Proceedings of the Engineers' Club of Philadelphia*, 1882, *Vol. III., pp.* 119–121.

Mr. Hering, having had occasion to inform himself upon this subject, and finding the experiments of the different authorities widely scattered, has collected the main points together in this paper. He concludes with a table of the resistance on different classes of roads. J. H. M.

WET COMPRESSOR WITH PARABOLIC COLUMNS.

Compresseur à Colonnes Paraboliques. Par M. G. HANARTE. *Bulletin Société des Ingénieurs Sortis de l'École Provinciale d'Industrie et des Mines du Hainaut, Sér.* 2, *Tome XIV., pp.* 59–64, *one folding Plate and three Diagrams.*

This paper gives an account of an improved form of wet compressor, which the author thinks will supersede the dry high-speed compressor of Collodon, which supplanted the original wet low-speed compressor of Sommeiller.

The principal improvement consists in substituting *evasée* columns of a parabolic form for the ordinary columns with parallel sides. By this means the velocity of the water is gradually decreased, eddies are prevented, and the compressor therefore can be driven at a higher speed.

The author gives a mathematical proof of the advantages of this form for the columns, and examples from places where it has been successfully applied in practice. J. H. M.

MINERAL WEALTH OF NEW SOUTH WALES.

New South Wales in 1881, *pp.* 61–70, *one folding Map.*

Chapter IX. of this official hand-book is devoted to an account of the mineral wealth of the colony. Gold and coal have hitherto been the principal productions; but tin, copper, iron, lead, silver, kerosene, precious stones, and a few other minerals are worked.

Coal extends over an approximate area of 23,950 square miles, and has been found of a quality second to none in the world. Professor W. A. Dixon, of the Sydney Technical College, says that it is denser than English Newcastle coal, representing an economic advantage of 6 per cent. for bunker purposes, and is practically sulphur free. The production has risen from 898,784 tons from twenty-seven mines in 1871, to 1,446,180 tons from forty-six mines in 1880. About 4,650 men are employed.

The map shows gold areas, mineral areas other than gold, agricultural areas, and pastoral areas. J. H. M.

THE AVAILABLE TONNAGE OF THE BITUMINOUS COAL-FIELDS OF PENNSYLVANIA.

By H. M. CHANCE, M.D. *Transactions of the American Institute of Mining Engineers, Vol. X., pp.* 144–162.

The author criticises former estimates, which he shows to have been much exaggerated. and, confining himself to easily accessible coal of good quality contained in beds thick enough for remunerative mining, he calculates the quantity remaining (at 1,500 tons per foot per acre) to be 33,547,200,000 tons, and the area of the field to be about 9,000 square miles. The details for each seam and for each county are given, and tables of probable future production estimated on a basis of 16,000,000 tons worked in 1880. J. H. M.

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ANALYSES OF NEW ZEALAND COALS.

By WILLIAM SKEY, *Analyst to the Geological Survey of New Zealand. Colonial Museum and Geological Survey of New Zealand, Seventeenth Annual Report*, 1882, *pp.* 24–28.

This paper contains analyses of thirteen bituminous and altered brown coals from Pictou, the Cheviot Hills, the Malvern Hills, Greymouth, Shakespeare Bay, Nightcaps Mine, Patria, Wharekawa, and Forty-mile Bush. J. H. M.

COALS IN MEXICO—SANTA ROSA DISTRICT.

By W. H. ADAMS, M.E. *Transactions of the American Institute of Mining Engineers, Vol. X., pp.* 270–273, *one Plate.*

Very little is known of this coal-field, which extends over hundreds of miles of country along the Rio Grande. The coal belongs to the Triassic formation, is semi-anthracite and bituminous, and of good quality.

The author is engaged at the Cedral Mines, the only extensive collieries in the district. The coal makes good coke, and he is now erecting fifty ovens.

The paper is illustrated by a map. J. H. M.

MINERAL PRODUCE OF NOVA SCOTIA.

By EDWIN GILPIN, JUN., A.M., F.G.S., M.R.S.C., *Inspector of Mines. Reports on the Mines of Nova Scotia*, 1881 *and* 1882, *p.* 1.

	1880.	1881.	1882.
	Ounces.	Ounces.	Ounces.
Gold	13,234	10,756	14,107
	Tons.	Tons.	Tons.
Iron ore	31,193	39,843	42,135
Manganese ore	223	231	205
Coal raised	1,032,710	1,124,270	1,365,811
Gypsum	128,528	107,133	133,426
Building stone	3,540	6,638	4,357
Barytes	—	40	—
Coke made	13,125	27,871	26,731
Fire-clay	75	401	—
Grindstones, etc.	1,500	1,680	2,450

J. H. M.

THE INFLUENCE OF A LOW BAROMETER UPON THE GEYSER AT MONTROND.

Influence des baisses barométriques sur les éruptions de gaz et d'eau au geyser de Montrond (Loire). Note de M. F. LAUR. *Comptes Rendus, Tome XCVI., 14th May*, 1883, *pp.* 1,426–1,428.

M. Laur has been making experiments upon this geyser since April, 1882, which show that it is affected by atmospheric disturbances, marking changes too delicate even to be detected by means of the barometer.

He considers that all geysers, volcanic eruptions, and the discharge of gases into mines are subject to this influence; and he points out that four colliery explosions happened during a period of atmospheric disturbance (13th April to 1st May, 1882), which was also accompanied by three eruptions of the geyser. J. H. M.

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